# THE PHYSICAL BASIS OF SOCIETY

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# THE PHYSICAL BASIS OF SOCIETY

BY

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# PREFACE

For many years the writer has been in the habit of beginning his University courses in Sociology by briefly sketching the physical background of life, the relation of the organism to its environment, the question of heredity, and the general idea of evolution as applied to human beings and the development of social theory. Because of the interest shown by his classes he has come to believe that there is perhaps a larger group which would welcome the opportunity to survey this field but which will not spend the time to gather the evidence which now exists in widely scattered volumes.

The real plagiarist is not the one who accidentally or willfully forgets to put quotation marks about given groupings of words, but he who gives the impression that the ideas conveyed are the result of his own thought-processes. I make no pretense to originality. I cannot remember the sources of many of my ideas, though I have tried to give due credit. It will probably be found that whatever is original is not good and whatever is good is not original. In reality I have sought to make accessible the best of modern thought on the questions involved even though this requires in some cases the presentation of conflicting views. I have tried also to indicate the limits of present knowledge and to point out the problems requiring further investigation before we can be very positive of our positions. I cannot even congratulate myself that I am acquainted with all the work that has been done and I have doubtless omitted much that should be included. More-

over, ere these pages are printed some investigator will probably have gotten new evidence of importance.

There is much reason to believe that we are approaching the time when a larger and truer viewpoint with reference to man and his welfare is possible. The chemist is no longer solely concerned with the study of the properties of matter and its compounds but is interested in the results of his studies on society; the ethnologist no longer merely makes collections of curiosities of savage tribes, but seeks to explain the course of social evolution; the historian no longer enthuses over dates and names, but seeks to trace the forces at work in shaping societies; the psychologist is turning from the description of mental phenomena to a consideration of human conduct. May we not anticipate sooner or later the appearance of the man who will do for the present century what Spencer sought with considerable success to do for the last, namely, correlate existing knowledge and show its bearing on man and his institutions? I doubt if that man is now living, or, at least, has reached maturity, but he is sure to come, for after all life is a unity and human welfare our greatest concern. If in any small way I have helped to suggest that unity and the desirability of such correlation I am well content.

Finally, I hope that I have succeeded in conveying the thought of the various sections without undue use of technical terms. I trust, therefore, that the general reader may find it worth while and at the same time that it may prove useful in clubs and classes which expect to make more detailed studies of some of the questions suggested in the later chapters.

Barring a few exceptions books only are included in the bibliography. It seldom happens that a book is twice

listed though many of them cover the discussion of several chapters.

In undertaking such a study a writer has his choice of two methods. He may undertake to tell the story in his own words or may allow the authorities to speak for themselves. The first method makes the reading somewhat easier. Inasmuch as no one can claim to have first hand information on so many subjects the reader is likely to wonder if the facts are as represented. I have preferred the second method, therefore, and have quoted freely from the best works known to me. Whenever possible I have drawn freely from the books of special value. Thus some pages of Chapter IV have been taken almost verbatim from the monumental work of A. D. White, " The Warfare of Science with Theology."

Special permission has been received from the following authors and publishers for quotations taken from works indicated:

Dexter, E. G. Weather Influences. Macmillan Company.
White, Andrew D. Warfare of Science with Theology. D. Appleton and Co.
Chapin, F. Stuart. Social Evolution. The Century Co.
Shelford, V. E. Animal Communities in Temperate America. Press of Chicago University.
Huntington, Ellsworth. Civilization and Climate. Yale University Press.
Cattell, J. McKeen. Article in *The Independent,* Sept. 27, 1915.

So many friends have helped me in so many ways that detailed statement is impossible. To them I owe the possibility of preparing these pages for the printer, and their assistance is gratefully acknowledged.

Carl Kelsey.

*Philadelphia, Pa.*

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# THE PHYSICAL BASIS OF SOCIETY

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## CHAPTER I

### EARTH AND MAN

In the year 1610 Galileo, using his newly made telescope whose lenses were smaller than those in our spectacles, began his study of Jupiter and was finally able to prove the theory of Copernicus and to show that the earth revolved about the sun. Up to that time the earth had been considered the center of the universe with the sun and stars revolving about it. Centuries before man had begun to count the stars and give them names but he little appreciated the size of his task. In 1914 the Royal Observatory of Greenwich calculated that the stars now known aggregate some 1,600,000,000, of which 3,000 or 4,000 are visible to the naked eye. Our minds cannot grasp such numbers for they are greater than the total of minutes since the birth of Christ.

These stars may be classified on the basis of the degree of heat. In the hottest, like two gaseous stars in the constellation of Argo, the spectrum shows lines belonging to no known element but bearing such relation to hydrogen that it is supposed to be a precursor thereof; hence these are called Protohydrogen stars. Helium is also present with hints of magnesium and calcium. In the helium-gas stars (Taurus, Algol) helium is prominent

along with hydrogen, while carbon, oxygen and nitrogen can be detected. The Protometallic stars (Riegel, Sirius) show such metals as iron, copper and calcium. The Metallic stars (Aldebaran, Arcturus, Sun) show the common metals and the proto-lines disappear, while the coolest groups have fluted spectra or, in other words, are too cool to show the characteristic lines of their elements. This same gradation can be produced under high pressure by electricity, and thus a glimpse can be had in the laboratory of the process of world-making. Watery vapors appear and on the planets bodies of snow and water are found.

It is our belief that the earth was once a molten mass whose surface has gradually cooled, and that this process left in the air and at the surface the materials of which organic beings are composed and thus prepared the basis for life. We must avoid the danger of assuming that this gradual cooling has been steady or uninterrupted. We know that North America went through several glacial periods when the temperature was much lower than that of today. We do not know what conditions are at the center of the earth, for our deepest borings have not carried us two miles below the surface.

In 1661 Boyle suggested in his "Skeptical Chymist" that underlying matter in all its forms were minute units by whose aggregation the masses were formed. By the first of the nineteenth century this idea was developed into the atomic theory by the school teacher Dalton to whom we are also indebted for our system of naming chemical compounds. For countless ages simple substances like copper, silver, gold and iron had been known but that there were really only a small number of substances on earth was not realized. In 1774 Priestly and

Scheel discovered oxygen. By the end of the century Cavendish had resolved water into its component parts. A few years later Davy, experimenting with his electric battery, discovered that all the common substances known as "earths" were compounds containing oxygen. Thenceforth there was a steady series of discoveries of elements whose qualities were noted and whose atomic weights it proved possible to determine. In 1868, by using the spectroscope, Johannsen of Paris found in the sun an unknown substance which he called helium and in 1895 Ramsey was able to show its presence on earth. The most striking of these discoveries was probably that of radium in 1898 by Madame Curie.

There are listed today some eighty-three elements which, so far as we can tell, are distinct. Nearly 99 per cent of the earth's surface including water (as the following table shows) is made up of eight of these, no other element contributing one per cent. Even such extremely important substances as hydrogen and carbon form only .17 per cent and .12 per cent, respectively.

| | |
|---|---|
| Oxygen | 47.02 per cent |
| Silicon | 28.06 |
| Aluminum | 8.16 |
| Iron | 4.64 |
| Calcium | 3.50 |
| Sodium | 2.63 |
| Magnesium | 2.62 |
| Potassium | 2.32 |
| | 98.95 per cent |

Some of the elements, like gold, are very passive and are seldom found in combination with others. On the other hand, some 60 per cent of known inorganic compounds contain oxygen; some 30 per cent, hydrogen. Many of these compounds possess very different properties from those held by their constituent elements, and

may themselves enter as units into more complex groupings. Some of the elements have not been found in nature save as compounds and man has reduced them in his laboratory. Aluminum, first produced in 1827, has become commercially important; while the metal calcium remains merely a curiosity. In like manner many possible compounds, not found on earth, have been made by the chemist. These elements existing throughout the universe, wherever found so far as we know, possess the same qualities and are governed by the same laws. Thus the earth is revealed to us as made out of the same "world stuff" as the planets and the suns. We know too that these elements (depending on temperature and pressure) assume solid, liquid or gaseous forms.

The discovery of the radio-active substances suggests that there has been an evolution of the elements and the belief is growing that they are perhaps but different forms of some common basic material. Radium appears to have been derived from uranium and seems itself to change into helium, and there is suspicion that the final product is lead. The atomic weight of the elements can be arranged in a complex series in a way that indicates that there must be some relationship. In some instances the absence of an element filling a given niche in the series has resulted in its discovery. We are beginning to speak of "electrons" and "ions" and to realize that matter is not the inert thing we have thought it to be. Radium gives off three classes of rays. The alpha rays seem to be minute bodies, positively electrified, which travel some 20,000 miles a second and may be stopped by a sheet of aluminum 1/500 of an inch in thickness. The beta rays are negatively electrified, travel 10,000 miles a second, and are stopped by a sheet of aluminum 1/25 of an

inch thick; while the gamma rays, apparently the same as X-rays, will pierce a plate of aluminum up to twenty inches or take a photograph through a foot of iron. Such facts are compelling us to wonder if force as well as substance is inherent in the concept of matter, and to realize that our chemical formulae do not fully describe the various substances.

With the growth of knowledge with reference to matter the physicist has discovered that those elements or compounds which enter largely into the structure of living organisms are not merely those whose properties enable them to maintain life but are the only ones possessing these properties. He emphasizes, therefore, the reciprocal nature of the relationship between the physical environment and the organism. Before considering this "fitness of the environment" we must note some of the characteristics of living organisms.

In earlier days life was considered as something entirely apart from matter, an outside spirit temporarily living in a material body; just as light and heat were interpreted as occult manifestations of some spirit. A great gulf existed at that time between organic and inorganic chemistry. In 1828 Woehler succeeded in producing urea from ammonium cyanate; in other words, synthetically created an organic compound up to that time known only as the product of living organisms. Today the chemist can create dozens of such compounds and the gulf between organic and inorganic is bridged even though we do not understand life itself. Body as well as spirit is inherent in the concept of life on earth and the existence and phenomena of living beings depend on the properties of matter, rather than on so-called "vital principles."

It is necessary then to think of the organism as an engine, made up of a multitude of parts, each having its own functions and the welfare of the whole depending on the proper functioning of each part. The foodstuffs must be transformed by a process of combustion (which we call digestion) into flesh, bone and energy. In this process there is the most wonderful coöperation between the different parts of the body. Even some very small organs, such as the ductless glands, until recently considered as of little importance, are now known to be indispensable. Thus the suprarenals, two glands not over one ounce in weight, situated above the kidneys, secrete adrenalin, a powerful constrictive having great influence on the arteries. Cretinism is produced by the nonfunctioning of the thyroids. Hypertrophy of the pituitary leads to giantism. The welfare of the whole body depends upon the performance of its own task by each portion thereof. That this is possible is due to the properties of certain compounds soon to be considered. We are able to see because the lens of the eye focuses the rays of light upon the retinal red and takes a picture, just as does the camera, which in some mysterious and wonderful fashion is recorded and filed in the brain. Life then may be conceived of as a series of chemical changes. In order that there may be permanency of the body there must be certain relatively unchanging portions; in order that new experiences may be had there must be instant and appropriate response to new conditions and stimuli.

On the earth today wherever and whenever conditions are favorable, there is life. The lowest forms are found either in water or under moist surroundings. Where the air is dryest the least life exists. If this has always

been so we must assume that when the temperature of water on the cooling earth dropped below the boiling point, 212°, the lowest forms appeared. The hydrocarbon group of compounds is then the first to attract our attention.

Pure air is composed of 79 parts nitrogen, 21 of oxygen and about .03 per cent of carbon dioxid with insignificant traces of argon, metargon, krypton and neon. Pure water is made of two parts hydrogen to one of oxygen. The human body contains carbon, 13.5 per cent; hydrogen, 9.1 per cent; oxygen, 72 per cent; nitrogen, 2.5 per cent; phosphorus, 1.15 per cent; sodium, 0.1 per cent; calcium, 1.3 per cent; magnesium, 0.001 per cent; iron, 0.01 per cent and traces of silicon and fluorin. Plants are composed largely of oxygen, hydrogen and carbon.

We may consider the maintenance of a fairly fixed temperature as one of the first conditions of life. Some of the bacteria live and multiply in water at a temperature of 32°, others prosper at 170°. Plants have their standard temperature which falls some 2 or 3° at night. The normal temperature of the human body is slightly above 98°, being lower at night and lowest in early morning hours. Muscular exertion raises the temperature about one degree. If the temperature rises to 105° we have a dangerous fever; if it is depressed to 93° the result is probably death. We perish from cold long before the body is actually frozen. To maintain this temperature a large part of the fats and carbohydrates in the food is burned (oxidized) within the body. Here the importance of water appears. By weight some 68 per cent of the body is water. An adult at rest weighing 165 pounds produces some 2400 calories (heat units) daily, enough

to raise the temperature of the body 57°. If the body were built of most substances, it would raise the temperature 180° to 200°. Man loses, therefore, about 1.5 calories per kilo per hour. Some of the elements in the body, moreover, would undergo marked changes if the temperature were much higher than it is. Our clothing does not give heat to the body, and is a better conductor of heat than air. It is chiefly of value because it keeps a thin sheet of air next to the body.

Of all known substances, water is best fitted to maintain an even temperature. Its specific heat is very high, being exceeded only by hydrogen and ammonia. If atomic weight is considered in addition, it stands at the top of the list. The freezing point of water is perhaps 100° higher than that of the average substance. This means that the latent heat of water is very high, being surpassed only by ammonia. Thanks to the expansion that occurs when ice forms, the actual freezing of more than the surface of a body of water is practically impossible. Water evaporates readily. It is estimated that at the equator some six and a half feet of water are taken yearly from the surface of the ocean. This spreads over the earth cooling the tropics and warming other regions. In these regards the only rival again is ammonia, but nowhere in nature is this found in large amounts. Edison states that the greatest discovery of the year 1913 was that of the method of producing ammonia directly from hydrogen and carbon. Water is a splendid solvent. It thus provides opportunity for many of the combinations necessary to life. Its surface tension (75), higher than any other substance save mercury (436), is very significant in view of capillary action enabling it to penetrate

the earth and the cells of organisms. Altogether, therefore, water seems to possess unique qualifications.

Another element of utmost importance to living organisms is carbon although this forms only .03 per cent by volume of the atmosphere and .01 per cent by weight of water. It is stated that over 100,000 compounds of carbon are now known. Some of these are very simple like carbonic acid ($CO_2$); others are so complex that a line would be required to write the formula. This element is peculiar in that it has the remarkable power of entering into union with itself as well as with other substances and is thus able to build up large molecules containing a great number of atoms which form the basis of living structures. The complex carbon molecules are relatively stable and thus give a needed permanency to delicate organic substances. "It is a curious fact in nature that there seems to be a position of greater stability when groups of six carbon atoms unite in little galaxies or concatenations. . . . Although such groups of less, or occasionally more, than six carbon atoms are formed naturally by life processes, by far the greater portion of the substance of living organisms is built up of six carbon groups and multiples of these." [1]

Carbonic acid enters and leaves water freely and is always associated with it. From the first "it has steadily fulfilled the function of regulating the reaction of protoplasm and of body tissue and fluids. The one chemical process which is open, if any transformations whatsoever are to be accomplished with carbonic acid and water, leads directly and to all appearances necessarily to the greatest complexity that has been found in any one chemical pro-

[1] Moore, B. Origin and Nature of Life, p. 105.

cess: to a system made up of possibly two hundred substances or more, most of which possess very great chemical activity." [2] The "unparalleled instability" of hydrogen and oxygen with the stability of some of the other factors makes possible the wonderful and delicate adjustment of the body between the conflicting demands of permanency and change.

The three great classes of food are the carbohydrates, the sugars and starches, which contain from thirty to forty of these great carbon groups joined together; the fats, formed by the substitution of hydrogen for part of the oxygen in the carbohydrates; and the proteins, which differ from carbohydrates and fats in that they contain nitrogen and sometimes phosphorus, sulphur and iron. Substances not in the food group or taken in excessive amounts must be eliminated. Here again carbon and oxygen play a great part. The lungs are stimulated into motion by carbonic acid. The oxygen enters and is carried through the system. The objectionable substances are broken down and burned to final products, usually carbon and water. We are not surprised to learn then that a man weighing 60–70 kilograms excretes daily: water, 2500–3500 grams; carbon dioxid, 750–900 grams; all other substances, 60–125 grams. Thus, in that wonderful process of building up and tearing down called metabolism, we gain the desirable elements and eliminate the harmful. *How* these elements are changed into living structure we know not — the *fact* has become clear. We are all familiar with the old illustration of the lily beautiful *in spite* of the mud in which it grows. We see that the lily is beautiful *because* of the mud. Did not these

[2] HENDERSON, L. J. The Fitness of the Environment, p. 219.

inorganic substances possess their peculiar properties, life could not be.

It was not enough for nature to furnish the basic elements of life. These had to be gathered together and made available. This leads us to the study of soils. A few plants like some mosses can live directly on rocks drawing their sustenance chiefly from the air. Opportunity for root growth is essential to the higher types. Soils have been produced by the disintegration of rocks and the decay of vegetation age after age in the place where the soil now is, or else they have been formed by the action of rain, wind and ice. We may thus classify the chief sorts:

| | | |
|---|---|---|
| Sedentary | 1. | Residual gravels, clays, sands |
| | 2. | Peat, muck, swamp soils |
| Transported | 3. | Alluvial |
| | 4. | Glacial |
| | 5. | Wind-blown, sand dunes, loess |

Soils of these various types will have different characteristics. The soil particles will vary in size from clay, so fine that it can scarcely be measured, to coarse gravel. They will vary in weight per cubic foot, exclusive of water, from peat at 40 pounds; clay, 75; half sand and half clay, 96; to siliceous sand, 110. The texture of the soil is fixed by the arrangement of its particles and this determines the moisture it may hold. In fine clay the pore space is about 50 per cent but in coarse sand only 25 per cent. Evaporation takes a large amount of water from the soil, hence a covering of fine particles helps to retain the moisture. For one ton of clover hay some 1560 tons of water are used. Here again the significance of water is indicated. Not merely does it furnish a large

part of the substance of the plants, but through the affinities of hydrogen and oxygen it combines with the various soil elements and makes them available as plant food. Once in a while the results are less happy. In countries of good rainfall the soluble salts of calcium, magnesium, sodium and potassium are leached out of the soil and carried off. In arid regions they are often brought to the surface and deposited as alkali which seriously checks and even prevents plant growth.

Inasmuch as plants must have certain chemicals it is evident that the fertility of the soil depends in part upon the amount of these present. If one essential is lacking, growth is checked, no matter how abundant the other elements.

In thirty-four soils analyzed by American chemists, the first eight inches of soil of an acre contained, on an average, potential plant food as follows: nitrogen, 3,217 pounds; phosphoric acid, 3,936 pounds and potash, 17,597 pounds; a total of 24,750 pounds or more than 12 tons.

Since these elements are taken out of the soil by plants year by year they must be returned in some way or else the soil will grow sterile. In good measure this is accomplished by the decay of the plants. The fact that the value of complete fertilizers manufactured in the United States increased from $26,318,000 in 1900 to $31,305,000 in 1905, or 18 per cent, indicates man's recognition of the necessity of replacing these food elements. Plant life soon shows any decrease in needed supplies by spindling growth, poor color and little fruit.

Different plants make different demands upon the soil. When the grains languish, while sorrel and oxeye daisy thrive, it is found that nitrogen is lacking. Recently we learned that the essential but not abundant element

nitrogen is drawn directly from the air by the leguminous plants: clovers, peas and beans. Thus the fertility of the soil is materially enhanced. Large amounts of lime will keep out chestnut, rhododendron or laurel, but will give a splendid growth of grass as is seen in the blue grass region of Kentucky. When grass fails and moss grows the wise farmer knows that lime is needed to correct the acidity of the soil. It is sour, as he says.

From the standpoint of the farmer, the soils have other important features. Some of the richest alluvial soils are so level that adequate natural drainage does not exist. Other districts are so hilly that cultivation is difficult and the land washes badly. Yet others are stony. Some retain moisture and may be heavy and cold. Others permit rapid evaporation and are light and warm. Whatever be the soil, the wise farmer knows the wisdom of using the crops adapted thereto and the methods of cultivation necessary under the given conditions for the best result. He knows that alfalfa will send its roots ten to twenty feet to water, while to produce corn it is necessary to have the water close to the surface.

With the exception of the tides, and possibly radioactive substances, the sun is the sole source of energy on this planet. Even the coal and petroleum, on which we depend for fuel and artificial light, are little more than stored up sun rays of bygone days. We may consider the influence of the sun in several aspects as: (1) controller of the orbit of the earth; (2) the source of light; (3) the source of heat; (4) the cause of the distribution of rain, and (5) the cause of wind and storm.

The rotation of the earth on its axis in its great course about the sun gives us the phenomena of day and night with its variation from twelve hours each at the tropics

to six months each at the poles. It gives us further the procession of the seasons with their varied characters. Here we have the basis for our measurements of time and the start of the mathematical sciences.

Light enables us to see and direct our movements. To a large degree it controls the growth of plants and animals. The construction of the substances we call proteids by the chlorophyll-holding plants takes place only in the light. The lower the temperature the greater the amount of light needed. The influence of light on the leaves causes them to draw many needed elements from the air. Thanks to the spectroscope we now know the spectrum of colors from red at the lower end to violet at the upper. Experiment has revealed that red and yellow light promote the assimilation of carbon dioxid. Under such light plants prosper as the following shows:

*(Mimosa pudica) Sensitive plants, seeds planted in May* [3]

| *Kind of Light* | *Red* | *Green* | *White* | *Blue* |
|---|---|---|---|---|
| | *Height of plants* | | | |
| Sept. 6 ..... | 0.22 m. | 0.09 m. | 0.04 m. | 0.03 m. |
| Oct. 22 ..... | 0.42 m. | 0.15 m. | 0.10 m. | 0.03 m. |

So necessary is the sunlight that few plants will survive if the tops are repeatedly cut, no matter how sturdy the roots.

In the Northern Hemisphere, the sun, shining longer and more directly upon the southern slope of hills, makes them much warmer than those of the northern slope. From the surface of water, or from cliffs and buildings, so much heat is often reflected that adjoining slopes are frequently much warmer than those removed from such influences. Reflection from the snow will sometimes blister one's face or produce the dreaded snow-blindness.

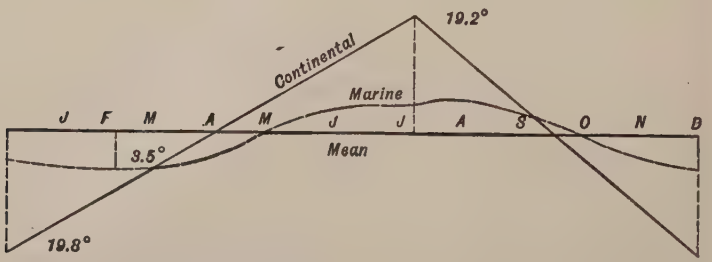
[3] HANN, J. Handbook of Climatology, p. 36.

The shady sides of forests or wind breaks are correspondingly cooler. Thus plant growth is hastened or checked.

The temperature determines the character of the vegetation. In the tropics one finds the characteristic plants with broad leaves and naked buds, of great size and continuous growth — a veritable riot of profusion, with woods so full of undergrowth that travel is difficult. Further north come the deciduous trees with protected buds, accustomed to endure both heat and cold, or spiny-leaved evergreens. Other things being equal, the nearer the pole the scantier and more dwarfed the vegetation. Periods of growth are followed by months of rest when the sap no longer runs. The woods no longer teem with underbrush save where the older trees have been destroyed. A similar change may be noted among the animals. Lizards and snakes gradually disappear along with the thick-skinned but practically hairless elephants and hippopotami. In their stead wolves, bears and fur-bearing animals appear. Gaudily colored birds are replaced by those of simpler dress; toucan and parrot yield to sparrow and grouse. In the world of water, sponge and coral are replaced by oyster and lobster; the ocean ferns by kelp. Hence we divide the plants in our gardens into three groups: tender, half-hardy, hardy. The first are peculiarly susceptible to frost (such as cannas); the second will endure moderate cold and occasionally survive if left in the ground over winter (gladioli); while the last are rarely injured, no matter how severe the cold (peonies). We may grow tropical plants out-of-doors during our hot summers, but we do not change their nature. With the advent of cold weather we must take them indoors or let them perish.

This succession of the seasons produces less effect upon

the temperature of the ocean than on land as may be illustrated by the following diagram.[4]




ANNUAL MARCH OF TEMPERATURE IN CONTINENTAL AND MARINE CLIMATES

The extremes of temperature are much greater on continental areas than on the ocean. In continental areas the maximum temperature is attained about one month after the sun reaches its highest altitude; the lowest about one month after its lowest declination. In marine areas the highest temperature comes a month or so later (August), while the lowest is not reached before March. In the interior of the United States the temperature of the winter months fluctuates more than 4.5° about the mean; in Russia, 6.3°; but in the coast climate of England only 2.7°. The ocean climate, therefore, changes less from day to day and its extremes are less. The temperature in large bodies of water varies to some extent with the depth. The temperature in Lake Michigan at the surface in summer is put at 64.9°; at a depth of 18 feet, 64.9°; 74 feet, 44.9°; 436 feet, 39.5°.

The different response of land and water to the rays of the sun sets up the movements we call winds or currents. In older times man thought: "The wind bloweth where

[4] HANN, J. o. c., p. 141.

it listeth," but now we have come to understand that these movements of air and water are in response to definite laws. To a large extent we have charted the ocean streams and understood why the Gulf Stream flows north, modifying the climate of the Atlantic Coast, while from the north comes a cold stream. The circulation in large bodies of water is significant inasmuch as the water absorbs oxygen at the surface. This must be carried to lower levels if fish are to survive. These currents are not well known today. The air currents are less thoroughly understood, though great progress has been made in mapping them since the middle of the nineteenth century. The United States is in the zone of prevailing west winds, which in large measure accounts for the cold climate of the eastern portion of the country in winter and its heat in summer. The wind, moreover, determines the distribution of the water taken from the ocean through evaporation and carried by the clouds. The presence of a high mountain range on the west coast stops the moisture-laden clouds from the west and creates a semi-desert to the east. Barring a little water from the north, all the rest for our great country must work north and west from the Gulf of Mexico and the Atlantic. The result is that west of the 100° meridian the supply is inadequate for ordinary crops. Another result is that the west coasts of America, as well as of Europe and Asia considered as a whole, are much warmer and subject to fewer extremes than the east coasts. We may compare two places to show this:

| | *Latitude* | *Mean Annual Temperature* | *Coldest month* | *Warmest month* |
|---|---|---|---|---|
| New York City.. | 40.8° | 51.08° | 35.06° | 75.38° |
| San Francisco... | 37.48° | 54.9° | 49° | 59° |

The city of London is covered with fog from 50 to 75

days a year. On the North Pacific coast 65 per cent of the days are cloudy; in the region of the Great Lakes, 50 per cent; Mississippi and Missouri valleys, 45 to 50 per cent; while Arizona and New Mexico have one of the sunniest climates on earth, only 30 per cent of the days being cloudy. Corresponding to this is the rainfall. On the North Pacific coast the rainfall is estimated at 60 to 100 inches annually; in the region of the Great Lakes, 30 to 40 inches; lower Mississippi Valley, 45 to 60 inches; upper Mississippi and Missouri valleys, 15 to 40 inches; Arizona and New Mexico, 10 to 20 inches and Eastern coastal plain, 40 to 60 inches.

Inasmuch as all life depends upon water, the question of rainfall is one of extreme importance. The annual average of seven to ten inches makes general agriculture possible, provided that the rain comes at the right time. A much heavier rainfall coming in a brief period followed by a long drought may prohibit the growth of plants. If the rains are light, the water may evaporate ere plant roots are benefited; if very heavy, they may beat down and destroy crops and wash the soil. Fog may bring little precipitation, but may produce many of the same effects and be very helpful, while dew prevents freezing ofttimes and also furnishes moisture. Granted then an adequate rainfall, under given conditions, an increase may produce greater results as this chart shows:

*Relation Between Annual Rainfall and Number of Sheep per Square Mile in Australia and Argentina*

| *District* | *Rainfall* | *Sheep per square mile* | *Increased capacity for each added inch of rain* |
|---|---|---|---|
| South Australia | Say 1st 8-10 in. | 8-9 (?) | About 1 sheep per sq. m. |
| N. S. Wales (1) | 9 + 4 | 96 | " 22 " " " " |
| N. S. Wales (2) | 9 + 4 + 7 | 640 | " 70 " " " " |
| Buenos Aires | 9 + 4 + 7 + 14 | 2630 | " 140 " " " " [5] |

[5] HANN, J. o. c., p. 58.

In the wheat districts the added yield was almost exactly the same as difference in inches of rain:

| | | |
|---|---|---|
| 6 bad years | 13.5 inches rain | 6.6 bu. per acre |
| 5 better " | 15.4 inches rain | 10. bu. per acre |
| 7 best " | 18.5 inches rain | 12.4 bu. per acre [6] |

Under dry farming conditions it has been calculated that

| | | |
|---|---|---|
| 1 acre inch water will produce | 2½ | bu. wheat |
| 10 acre inch water will produce | 25 | bu. wheat |
| 15 acre inch water will produce | 37½ | bu. wheat |
| 20 acre inch water will produce | 50 | bu. wheat [7] |

The total reduction in the corn crop of the United States in 1913 owing to the drought of that year was estimated at 750,000,000 bushels. In one place in Kansas the thermometer stood at 100° or over for 64 days, while the total rainfall between July 1 and September 7 was 0.03 inches.

In Jamaica with 56 inches of rain, sugar yielded 1,441 casks per acre; with 76 inches, 1,559.[8]

In marine climates wheat is said to contain 9 to 12 per cent of protein, while in Russia and Hungary it is 4 to 8 per cent richer. Hot, dry climate decreases the proportion of starch and increases that of gluten.[9]

Moist tropical valleys sheltered from the wind may be very unhealthful owing to the growth of lower forms of life. A similar situation in other zones may give happy results. "In times of calm, the air temperature may itself be quite unimportant. An unobstructed exposure to solar radiation, combined with a calm condition of the atmosphere, makes it possible for certain high valleys in the Alps, which are especially well sheltered, to rival

[6] HANN, J. o. c., p. 58.
[7] BAILEY, L. H. Farm and Garden Rule Book, p. 34.
[8] HANN, J. o. c., p. 58.
[9] Ibid., p. 141.

many southern winter resorts, notwithstanding the extreme cold of the winters." [10] In California the Napa Valley north of San Francisco produces some of the earliest fruit for like reasons.

In damp climates the water in the air forms nearly 3 per cent of the whole by volume while in Central Europe the percentage is only 1.3. The percentage of carbon increases during fogs. Air ordinarily contains many impurities, both inorganic and organic. In a cubic meter of air in the Alps one observer found 345 bacteria per cubic meter, whereas in Paris 4,790 were found. One of the great services performed by rain is the cleansing of the air by removing these impurities. The air of the desert and the ocean is very pure. The presence of ozone indicates the absence of organic impurities, and ozone is not to be found in inhabited rooms. In the Alps it is found to be four times as common as in Paris. Hann shows the extent of the contamination of the air in cities by the following table:

*Impurities in Air, Feb., 1891. Greenhouses at Chelsea and Kew Deposits Equal to 22 Lbs. per Acre, or 6 Tons to Mile* [11]

| | *Chelsea* | *Kew* |
|---|---|---|
| Carbon | 39. | 42.5 |
| Hydrocarbons | 12.3 | 4.8 |
| Organic bases | 2. | |
| Sulphuric acid ($SO_3$) | 4.3 | 4. |
| Hydrochloric acid (HCL) | 1.4 | 0.8 |
| Ammonia | 1.4 | 1.1 |
| Minerals (silica-iron) | 33.8 | 41.5 |
| Water (est.) | 5.8 | 5.3 |
| | 100.0 | 100.0 |

The soot deposit each year in central London is estimated at 426 tons per square mile; in Leeds at 539; in

[10] HANN, J. o. c., p. 38.
[11] Ibid., p. 77.

Glasgow at 820 and in Pittsburgh at from 595 to 1940. The smoke at Pittsburgh contains about 3,000,000 tons of sulphur yearly or enough to dissolve 265,000 tons of structural iron. The damage done is estimated at $10,000,000. The city of Los Angeles gets from 60 to 75 per cent of all possible sunshine, while Pittsburgh gets from 35 to 58 per cent.

It is quite as necessary for the florist to control the moisture as the temperature if he would grow plants under glass. Some plants demand much more moisture than others. This fact gives humidity some of its most important indirect effects. In a given locality an excess of rain above the average may promote the growth of poisonous plants. In Montana the stockmen have long realized the increased frequency of trouble due to the larkspurs, water hemlock, loco weeds, and poison camas. Excess moisture is very likely to lead to epidemics of disease because of the fact that under such conditions the plants or animals causing disease and the types carrying the disease flourish. In Africa the sleeping sickness is carried by the tsetse fly inhabiting the banks of streams and ponds. Malaria disappears in the Middle West when the marshes are drained and the land cultivated. Indeed, the disappearance of the great hordes of horses that once inhabited North America long before the advent of man is best explained on the basis of some disease; and it is interesting to note that fossil flies similar to the disease-carrying flies of Africa (*glossina*) have been found. In other words, moderately dry conditions have always been most favorable to the higher types of life. "It is a matter of universal observation that in tick or insect-infested countries dry seasons result in the reduction, moist seasons in the increase of diseases; dry localities

are in greater danger from wolves when the snow is deep.

Besides driving the rain clouds the winds produce other effects. They greatly increase the evaporation of water and thus affect the humidity of the air. They cause more rapid conduction of heat from the body and thus increase the sensibility to lower temperatures, while if the temperatures are high their effect is pleasing. Some animals hide when the wind blows. To some extent the winds control the distribution of such animals as moths and butterflies and also of plants. They have marked effects on human beings as will be shown later.

Temperature is perhaps the most influential factor in determining the distribution of life. This has varying aspects. Indirectly it may control the habitat because of food supply. Many birds could easily spend winter north of the 40° latitude if the food supply were adequate. Robins, blackbirds, meadow larks, turtle doves and others occasionally remain in mild winters in greatly reduced numbers. The codfish have a temperature of about 37°. They refuse to remain in water that falls to 32°. In 1882 a section of the Atlantic 170 miles in length by 25 in width was covered with dead "tile-fish" (*Lopholatilus chamæleonticeps*) the total number being estimated at 1,400,000,000. They live at the edge of the Gulf Stream at a depth of about 600 feet. In this year the Gulf Stream seems to have shifted its course with the result above stated. In 1892 it resumed its old course and since that time the fish have increased again, being present in large numbers in 1915.

In America, north of southern Mexico, there are seven transcontinental life zones: three boreal, three austral and one tropical; "each characterized by particular associa-

tions of plants and animals." These belts are determined by the temperature. In the development of plants all temperatures above 42.8° are important.

| | | |
|---|---|---|
| Tropical ..... | 26,000° | hottest period over 78.8° |
| Lower Austral ..... | 18,000 | hottest period over 78.8 |
| Upper Austral ..... | 11,500 | hottest period below 78.8 |
| Transition ..... | 10,000 | hottest period below 71.6 |
| Boreal — below ..... | 10,000 | hottest period below 64.4 [13] |

The *Biological Survey* is endeavoring to trace as accurately as possible the actual boundaries of these areas, and is preparing lists of the native animals and of agricultural products that are adapted to each.

A most important phase of temperature is its influence on reproduction. The distribution of animals turns not so much on the mean annual temperature as on the mean temperature during the period of reproduction and infancy. Thus the northward spread of tropical plants and animals is limited by the cold of the north, while the southward extension of colder types is limited by the heat. Merriam has called this the "law of temperature control," and he thus states it: "Temperature by controlling reproduction predetermines the possibilities of distribution; it fixes the limits beyond which species cannot pass; it defines broad, transcontinental barriers within which they cannot exist, be the other conditions never so favorable, because of infertility." [14] Many plants of warmer regions will grow in colder regions but without producing seed. It was noted, long before the cause of the disease was discovered, that yellow fever stopped with the oncoming of frosts in the fall. The whale breathes air, yet cannot live out of water. This

[13] Merriam, C. H. Life Zones and Crop Zones, pp. 54–55.

[14] Merriam, C. H. In Osborn, o. c., p. 504.

is due to the heat produced by the sun. The fat protects the whale in water, but kills it in the air.

Thus far in the discussion emphasis has been placed upon the physical factors which control and regulate life. If we change the viewpoint and consider primarily life itself, we will be led to speak of adaptation. Really then control and adaptation are but varying aspects of the same process.

There are but two sources of oxygen, air and water, and the first great adaptation is to one of these. The lowest forms of life have little specialization of organs so far as we can judge, but in the higher forms we find either lungs or gills. The whale may live in the ocean, provided it comes to the surface to breathe; the flying fish may dart into the air, but must soon seek the wave. The fish does not decompose the water in breathing, but utilizes only the free oxygen carried by the water. Water absorbs and holds various gases. Brook trout thrive if there are 5 c.c. of oxygen to the liter, while if there are 5 c.c. of carbon dioxid to the liter of water, the fish are driven out. Plants thrive by virtue of the carbon dioxid present in water. In an aquarium there is frequently an excess of nitrogen, which causes suffering to the fish. Moreover, the air or water must be of fairly uniform character if the best results are to follow. Pure water like pure air can hardly exist outside the laboratory. Water contains not merely sand and dirt, but likewise numberless substances held in solution, of which the commonest is salt. Few plants or animals accustomed to fresh water can exist in salt, while few of those in the ocean could survive in Great Salt Lake. If the streams are polluted with acids, coal, dirt and filth, the fish soon leave or perish. The fumes from a smelter may destroy

vegetation. Stone cutters, coal miners, painters and men who work in the dust of streets breathe in so much foreign matter that their lungs are coated, the supply of oxygen thereby reduced and they are made susceptible to the attacks of germ diseases, if not actually poisoned by the substances inhaled, as in the case of phosphorus or lead.

In the ocean and lakes there appears to be a pretty definite stratification of life, certain types being always found near the surface, others at lower depths while some are found only far below the surface. This is shown by the following table:

*Stratification of Fish in Lake Michigan*

Lake Herring (*Argyrosomus artedi*)
Whitefish (*Coregonus clupeiformis*) 21–36 meters; spawning 15–19 meters usually
Lake trout (*Cristivomer namaycush*) below 25 meters, except during breeding season (2–25 meters)
The Long-jaw Whitefish (*Argyrosomus prognathus*) 36–66 meters
The Blackfish (*Argyrosomus nigripinnis*) 70–80, rising to 60 in December
Hoy's Whitefish (*Argyrosomus Hoyi*) — Usually below 115 meters
Small Cottoid (*Triglopsis Thompsoni*) — Below 115 meters [15]

Possibly intensity of light is responsible for the stratification just mentioned, for it seems these dwellers of the depths come to the surface only at night. Practically no light rays penetrate more than 350 feet below the surface of the water. Owls can see by day, but greatly prefer to hunt at night. The lowly forms of life dwelling beneath the surface of the ground have, like the moles, little use for eyes, while the same is true of the blind fish of Mammoth Cave. Parasitic forms that live within the bodies of animals can seldom stand direct exposure to light for any length of time. The germs of syphilis and

[15] SHELFORD, V. E. Animal Communities in Temperate America, p. 82.

tuberculosis are soon killed by sunlight. If a cockroach is set free it will seek the shadow, while the fly goes to the light. In ponds the snails seek a faint light, being found in the lightest spots on the darkest days.

Activity is determined by structure. The fish swims because it is so constructed that it can't help swimming if it moves. We have no reason to think it prefers swimming to walking. For the same reason, birds fly and man walks or runs. It is evident that this coördination has not been produced by the organisms themselves, consciously at least. In the main, they do what they do because of what they are. In the case of lower types they may be carried by wave, wind or animal agency to uncongenial regions and perish. But the higher forms by their power of motion may place themselves in such situation that harm or death must follow. Complete self-realization even for man himself then depends upon maintaining a condition of adaptation. From this there is no exception unaccompanied by penalty.

"If animals are placed in situations where a number of conditions are equally available, they will almost always be found living or staying most of the time in one of the places. The only reason to be assigned to this unequal or local distribution of the animals is that they are not in physiological equilibrium in all the places." [16] Its habitat then is selected by "trial and error," that is if it does not feel comfortable in one place it seeks another till at length, perhaps, it feels content. Animals of the same species will show different habits in different environments. "Animals living in the same places, and apparently under the same external conditions of existence, nevertheless behave in quite different ways under

[16] SHELFORD, V. E. o. c., p. 31.

the influence of the various substances held in solution of the water, as salt, oxygen, carbonic acid, etc. The ova of different and yet very closely related forms can endure a long period of drought, or even require it to enable them to develop. Hence, every change, as for instance, in the composition of the water of a lake or river will not affect the fauna inhabiting it equally and as a whole, but will act on some individuals; some will bear the change without being in any way affected by it, others will die, while others again will survive." [17]

We must now consider more directly in what ways man himself is influenced by the physical world and for purposes of discussion we may divide this into five heads: (1) distribution and migration, (2) occupation, (3) direct physical effects, (4) physiological effects, (5) psychical effects.

1. *Distribution and Migration.*— The common belief is that the human race arose in some one area. Even if this be true, we must recognize that in prehistoric times man had made his way to every part of the earth. Though the density of population turns in part on the stage of culture, it is interesting to note his present distribution.

*Approximate Density of World's Population, 1911*

| *Continent.* | *Area in Sq. M.* | *Population* | *Pop. per Sq. M.* |
|---|---|---|---|
| Europe | 3,833,567 | 463,997,000 | 121.0 |
| Asia | 16,997,639 | 962,233,000 | 56.6 |
| Africa | 11,760,689 | 135,987,000 | 11.6 |
| North America | 8,631,657 | 127,993,000 | 14.8 |
| South America | 7,184,021 | 51,193,000 | 7.1 |
| Australasia | 3,317,762 | 7,572,000 | 2.3 |
| Total (excluding Polar regions) | 51,725,335 | 1,748,975,000 | 33.8 |

The frigid zones, deserts, high mountain ranges,

17 SEMPER, K. Animal Life, p. 176.

swamps, water surfaces are sparsely populated, if at all. Most mountain districts impose hard conditions upon men. In Switzerland the mountain cantons show the smallest population per square mile (Grisons, 38; Uri, 48; Valais, 59); while those on the marginal plains are relatively crowded (Zurich, 705; Geneva, 1,356). In England: Westmoreland (85); in Wales: Radnor (49); and in Scotland, Sutherland (11) again show the hill country, for the average density in Great Britain is 374. In Switzerland only 15 per cent of the land can be cultivated and the same is true of Japan. In Norway 67 per cent of the total area is in bare mountains, lakes, snow fields or bogs, 7.6 per cent in pastures, 2.2 per cent in meadows and 7 per cent in grain fields. The dense populations of earth are found in the lowlands below an elevation of 600 feet: in China, the valleys of India, the valleys of the Po, the lowlands of France, Germany and England where the population is over 385 per square mile. The different states in America show the same contrast. We may compare Rhode Island (508), Massachusetts (418) and New Jersey (327) with Montana (2.6), Idaho (3.9) and Louisiana (36.5). Wherever a heavy population is found in the Piedmont between the lowlands and the mountains it is due to the development of mineral resources. Birmingham, Alabama, is a good illustration of this. Unless forced by his enemies or driven by pressure of population, man is very slow to enter the mountains as places of permanent residence. Hence any group getting located in the mountains is likely to drop out of touch with the development of the balance of the country and become "our contemporaneous ancestors" as the inhabitants of the southern Appalachians have been called.

Man's movements on earth have been directed and controlled by physical conditions. High mountain ranges have offered next to the ocean the greatest barriers. Hence has arisen in human history the importance of passes. Thermopylæ renowned in Greek literature, the Brenner Pass through which the Germans made their way to the Po Valley, the Dariel Pass in the Caucasus, the Cumberland Gap, the Mohawk Valley and Truckee Pass, through which the California trail in the 40's led, are but a few of historical importance.

In times of peace the passes are the great trade routes determining the location and prosperity of many settlements. The Brenner Pass was largely responsible for the commercial life of Augsburg, Ratisbon, Nuremberg, Leipzig and, in part, Venice. Through the low Mohawk Valley, 445 feet above sea level, was the line of march to the Great Lakes and the West. The district became densely populated while the neighboring Catskills were nearly empty. Because of this great highway Albany, Troy, Utica, Rochester and Buffalo came into being. Had the St. Lawrence been navigable to the lakes and its mouth free from ice the entire development of North America would have been changed, so much does nature determine man's movements. First the animals for ages making their way through the hills, then uncivilized man in pursuit of game, then the trapper and frontiersman following in their trail; then probably the army officer discovering a pass and then the surveyor and the railroad, all following the road indicated by nature. In dozens of places on earth just this development has ensued.

For long ages navigable rivers have been favored highways. Wherever the fall line was encountered at the edge of the hilly Piedmont country there too has man

built his towns. The Atlantic Ocean has a drainage basin of over 19,000,000 square miles, while the Pacific has only 8,660,000. Rivers facilitate trade and intercourse. Africa has nothing to compare with the Amazon or the Missouri. The Yangtse and Hoangho are the source of China's prosperity as was the Nile of ancient Egypt.

Islands in favorable climes are densely populated. Java has a density of 587 to the square mile; Gilbert Islands of Great Britain, 1254. The Islands of Denmark have a density of 269 as compared to 112 in Jutland on the mainland. Safety and fish are probably the two chief factors in causing this density.

Until the sixteenth century the oceans were practically impassable, until the nineteenth, impassable to all but a handful; yet man has at some time and somehow made his way to all habitable parts of the earth.

2. *Occupation.*—"Geographic conditions influence the economic and social development of a people by the abundance, paucity or general character of the natural resources, by the local ease or difficulty of securing the necessities of life, and by the possibility of industry and commerce afforded by the environment." [18] The history of America affords endless illustrations of the truth of this statement. The New England States turned from agriculture to manufacturing and shipping, they found slavery generally unprofitable and they developed the town and town meeting as their type of government; while substantially the same people in the south clung to farming largely because of the adaptability of the land to tobacco and cotton, welcomed the Negro slaves and made the county the unit of government, the scattered house-

[18] SEMPLE, E. T. Influences of Geographical Environment, p. 43.

hold the ideal of life. There is no more interesting contrast in our history than the antagonisms between the hill whites and the lowland slave owners, indicated by such events as the separation of West Virginia from the mother state and by the fact that some of the mountain counties of Tennessee furnished as large a percentage of Union volunteers in proportion to population as did any northern district. Since man must live on the "free goods" of nature to be had by the taking or must produce for himself, it is easy to see that the life of the Eskimo must differ widely from that of the West African Negro. In Polar regions man must even today be a fisher and hunter, living on meat alone, unless he keep in touch with other people, when he may be a miner. On the whole the temperate zones have been most favorable to him, and no great civilization has arisen as yet in the tropics. By fixing the opportunities nature goes far towards determining the type of the development.

3. *Direct Physical Effects.*—"We can hardly err in attributing the great lung capacity, massive chests and abnormally large torsos of the Quichua and Aymara Indians inhabiting the high Andean plateaus to the rarefied air found at an altitude of 10,000 or 15,000 feet above sea level." [19] It is well known that the different parts of the body grow and mature at different rates and times. If food, heat or clothing be lacking, a stunting may result. Alpine or boreal races are usually shorter than those of the lowlands of warmer regions. Transfer to a new country may cause marked changes for reasons not yet fully understood. In America the descendants of Europeans are seemingly considerably larger than the average at home. This was indicated by the soldiers in

[19] SEMPLE, E. T. o. c., p. 34 ff.

the Civil War. Professor Boas of Columbia University has been studying recent immigrants. He writes: "I think, therefore, that we are justified in the conclusion that the removal of the East European Hebrew to America is accompanied by a marked change in type, which does not affect the young child born abroad, but which makes itself felt among the children born in America, even in a short time after the arrival of the parents in this country. The change of type seems to be very rapid, but the changes continue to increase so that the descendants of immigrants born a long time after the arrival of the parents differ more from their parents than do those born a short time after the arrival of the parents in the United States." [20] These changes are in the shape of the head form, hitherto considered very fixed. The Hebrew becomes more long-headed, the Italian more round-headed. Such striking conclusions need a verification, yet lacking, before being unqualifiedly accepted. The Snake Indians of the Rockies differed much in stature from the Blackfeet or Sioux of the plains.

The environment by fixing occupation may in large measure determine physical characters. Darwin attributed the thin legs of the Indians of the Paraguay River to the constant canoe life. The man who lives in the saddle acquires a rolling gait when walking as does the sailor. The stooping shoulders of the farmer are likewise due to his trade.

A very important and practical question which cannot be finally answered at the present time is whether the blond types of humans can survive in the tropics. In part this is a question of control of disease but it has other aspects. There is some reason to believe that the

[20] Boas, F. Changes in Bodily Form, p. 52.

white races cannot permanently endure the constant heat and the effects of the actinic rays of the sun. "Consequently we find that man is invariably covered with a pigment which acts as an armor to exclude the more harmful short rays, and moreover the amount of pigment is in direct proportion to the intensity of the light of the country to which his ancestors have proved their adjustment by centuries or millenniums of survival in health and vigor. It is a simple matter of mathematics to show that the intensity of light under the zenith sun in the tropics is the greatest and that the proportion of rays per unit of surface diminishes as we go north in proportion to a function of the latitude. In addition to this the further from the tropics we go the greater is the layer of air which the rays must pass through and the more of them which are absorbed. . . . Undoubtedly the Negro, when in the shade, is able to radiate heat better than whites and this enables him to keep cool in the tropics, but puts him at a disadvantage in the north where a white man can keep warmer with less clothing and less fire in the house. But it is a secondary cause enhancing the first, because when it comes to a question of light and cold, nature makes no mistake, but selects a color to exclude the light. Hence in all cold, light countries, i.e., steppes, plains and the arctics, there is pigmentation of a color in the lower end of the spectrum, red or yellow, with variations of brown, olive or copper. . . . All these red and yellow colors undoubtedly enable the native to conserve his heat almost as well as the white man, and at the same time, exclude the dangerous short waves." [21] Though the individual man may prosper for a time in the tropics

[21] WOODRUFF, C. W. Effects of Tropical Light on White Men, p. 85 ff.

it may be that there is some deep seated reason for the absence of third generation Europeans in India. Our experience with the polar regions is too meager to give us the basis for an opinion as to their effects on the race.

The barometric pressure at sea level is 29.38. The ordinary changes in pressure are too slight to be noted. Yet most people have momentary discomfort when descending in an express elevator from the top of a high building. Serious results ensue from sudden changes of altitude. During the construction of the tunnels under the Hudson one physician is stated to have seen 2,400 cases of "caisson disease," popularly known as the "bends," resulting from working under unusual pressure; while Younghusband's account of the British expedition to Thibet gave many amusing accounts of the attempts of sea level dwellers to march and fight at high altitudes. Railroad circulars seldom mention the danger of going to the top of Pike's Peak, but physicians are better informed. Prolonged residence in high altitudes is thought to produce definite effects, inasmuch as the blood gets more oxygen and gives off more carbon dioxid.

4. *Physiological Effects.*—In spite of the considerable overlapping with the purely physical effects it seems wise to consider certain types of influences under this caption. Every one is conscious that his feelings vary from day to day and that they are influenced by climatic conditions. Of Buenos Aires, Dexter writes:

"By the time the north wind has reached the city it has become so overcharged with moisture that everything becomes intensely damp. The effects produced in the human body are a general lassitude and relaxation, opening the pores of the skin and inducing great liability to colds, sore throat and all consequences of checked perspira-

tion." Of the dry winds of Colorado he says: "During the prevalence of such, the humidity is invariably excessively low, and in the dry air there seems to be set up, by the movement of the wind particles and the leaves and grasses set in motion by them, an electrical state which in some undetermined way makes havoc with the emotions." [22]

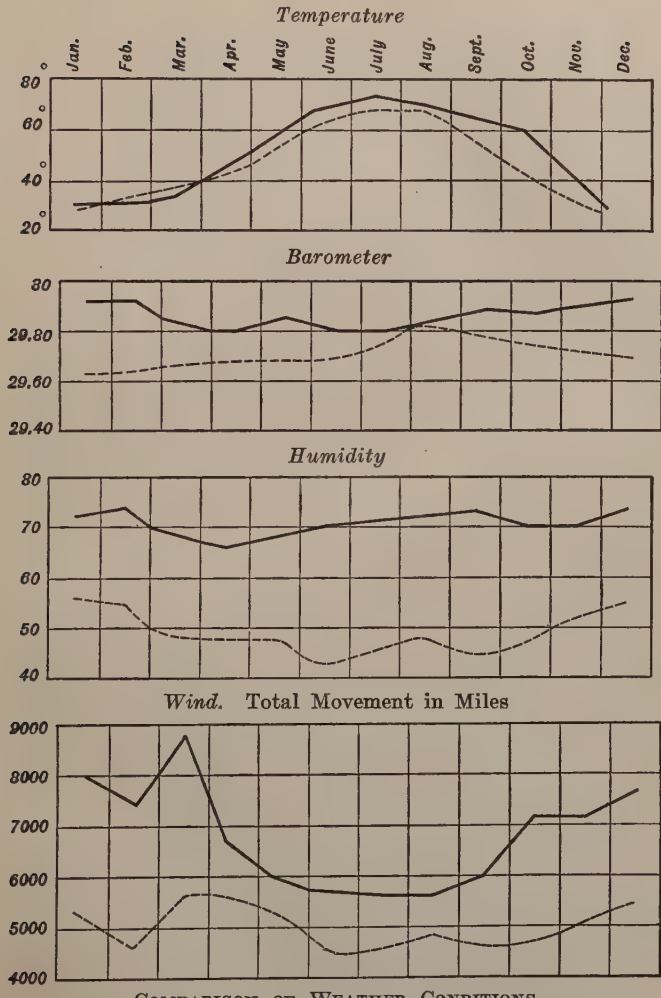
In similar fashion, Huntington writes: "In eastern Turkey the hot desert wind causes the whole community to become cross and irritable. I have there seen a missionary, a man of unusual strength of character, shut himself up in his study all day, because he knew that he was in danger of saying something disagreeable." [23] Similar reports come from Italy.

Hann claims: "Damp air and increased pressure have the following physiological effects:—nervous depression; quiet sleep; increased elimination of carbon dioxid; slower circulation of the blood. Dry air and decreased pressure, on the other hand, have these effects: — nervous excitement; sleeplessness; quickened pulse; a dim skin and a decreased temperature." [24] Dry cold and dry heat are relatively easy to endure.

There seems to be reason to believe that the connection between climate and behavior may be more clearly understood in the future. Many students have attempted to establish the relationship but their evidence has been too vague and fragmentary to justify very definite conclusions. The contrast shown by the charts on page 37 may well lead us to expect different reactions in the residents of New York and Denver.

Hellpach has collected considerable evidence showing

[22] Dexter, E. G. Weather Influences, pp. 81–82.
[23] Huntington, E. Civilization and Climate, p. 47.
[24] Hann, J. o. c., p. 57.




COMPARISON OF WEATHER CONDITIONS [25]
in New York City (——) and Denver (....).

the influence of the advent of spring and summer on conduct which indicates that some real causes are at work:

[25] DEXTER, E. G. o. c., p. 88.

| *Conceptions (Germany)* | *Jan.* | *Feb.* | *Mar.* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Legitimate | 100 | 99 | 99 | 103 | 106 | 104 | 100 | 97 | 95 | 95 | 98 | 105 |
| Illegitimate | 91 | 95 | 103 | 110 | 116 | 109 | 104 | 100 | 95 | 91 | 88 | 100 |
| *Suicides.* | | | | | | | | | | | | |
| France | 68 | 80 | 86 | 102 | 105 | 107 | 100 | 82 | 74 | 70 | 66 | 61 |
| Italy | 69 | 80 | 81 | 98 | 103 | 105 | 102 | 93 | 73 | 65 | 63 | 61 |
| Prussia | 61 | 67 | 78 | 99 | 104 | 105 | 99 | 90 | 83 | 78 | 70 | 71 |
| *Sexual Offenses.* | | | | | | | | | | | | |
| Germany | 64 | 66 | 78 | 103 | 128 | 144 | 149 | 130 | 108 | 90 | 68 | 69 |
| Italy, per cent. | 5.5 | 5.2 | 6.8 | 8.5 | 10.9 | 13. | 12. | 11. | 8.9 | 7.2 | 4.9 | 5. |
| *Insanity* | 1476 | 1490 | 1829 | 2237 | 2842 | 2901 | 2614 | 2261 | 1604 | 1637 | 1452 | 1529 |
| *Artistic Creations* | 101 | 82 | 103 | 134 | 149 | 125 | 105 | 113 | 138 | 83 | 103 | 86 |
| *Mental Feats* | 99 | 78 | 96 | 122 | 137 | 106 | 96 | 109 | 119 | 80 | 101 | 82 |

INFLUENCE OF THE SEASONS UPON CONDUCT [26]

[26] HELLPACH, W. Geopsychischen Erscheinungen, p. 349 ff.

It seems impossible to explain the marked rise in all the tables in April as a mere coincidence.

Very recently Huntington has published the accounts of a very valuable study made by him of the actual work throughout the year of some five hundred factory operatives in Connecticut, some three or four thousand in cities from Virginia to Florida and some 1,700 students at West Point and Annapolis (the students' records being limited to the school year). His results were compared in great detail with the weather conditions. He found that barometric changes showed little influence, that humidity was of considerable importance, but that temperature was more decisive. It was found that all these groups were physically most active when the average temperature was from 60° to 65°, that is, when the temperature at noon was 70° or over. Mental activity reached its maximum when the outside temperature averaged about 38°, that is, with frosts at night. He found that steady temperature was not favorable and that the best work was done when there was some daily change but sudden violent changes were not beneficial. Moderate changes with frequent cooling of the air gave the best results. There was a marked reduction of the work in very dry weather. Very cold weather was unfavorable and more work was accomplished on cloudy than on bright days.[27]

On the basis of his studies Huntington believes that the most important climatic factors are: (1) the mean temperature month by month; (2) the amount of change from day to day and (3) the relative humidity.[28]

He then proceeds to map the world to see in what places the best conditions are found, that is where the

[27] HUNTINGTON, E. o. c., p. 8 ff.
[28] Ibid., p. 137.

DISTRIBUTION OF HUMAN ENERGY ON THE BASIS OF CLIMATE

greatest energy will be developed. He finds five such areas: (1) western and central Europe to the borders of

Rumania and northern Italy; (2) North America east of the Rockies from southern Canada to the thirty-eighth parallel; (3) the Pacific Coast; (4) Japan and (5) New Zealand and the adjacent corner of Australia.[29] It is most interesting to note that these are the seats of the most progressive civilizations of today.

No matter what modifications further study may necessitate it would seem that at last we are reaching the point where definite measurements may be made of man's reactions to the physical world, and we may hope for much greater knowledge in the near future.

The question of survival in the tropics has been mentioned. That change of residence from the temperate zones to the tropics may have pronounced effects is undoubted. "Practically every northerner who goes to the Torrid Zone says at first that he works as well as at home, and that he finds the climate delightful. He may even be stimulated to unusual exertion. Little by little, however, he slows down. He does not work so hard as before, nor does the spirit of ambition prick him so keenly. On the low, damp seacoast, and still more in the lowland forests, the process of deterioration is relatively rapid, although its duration may vary enormously in different individuals. In the dry interior the process is slower, and on the high plateaus it may take many years. Both in books and in conversation with inhabitants of tropical regions one finds practical unanimity as to this tropical inertia, and it applies to both body and mind." [30]

5. *Psychical Effects.*— Man is often strangely reluctant to admit that earth exercises any control over his ideas. Yet a moment of reflection will show that there

[29] HUNTINGTON, E. o. c., p. 250 ff.

[30] Ibid., pp. 41–42.

are such influences. All our knowledge is mediated by the senses and finds its source in the world about us. Even our imaginations are bounded by details which we gain by personal contact or in some indirect way. We never dream of anything really new. All we can do is to put together in some new combination the elements with which everyday life has made us familiar. On the Isle of Man in days gone by the stealing of a pig or chicken was punished by death, while the stealing of a horse was only a minor offense. This grew out of the fact that the horse could not be taken off the island without detection nor could it be long concealed. The people accustomed to the awful heat of the desert pictured the place of punishment of the next world, Hell, in terms of heat; while the Eskimo, accustomed to great cold, thought a place of constant heat would be most desirable and to him it became Heaven. Our languages will show our main interests. The Samoyedes of northern Russia have a dozen terms to distinguish the shades of brown and gray of their reindeer, while the Malay vocabulary is rich in nautical terms. Our language reflects also the relative development of our senses. The qualities of colors, the vibrations of tones are carefully worked out and we have a great series of descriptive adjectives. On the other hand, so defective is our sense of smell that accurate definitions of odors are practically impossible. "In all the forms of its creeds and cults, humanity does not seem to be able to get away from its earthly patterns. The Elysian fields, the Valhalla, the life that now is reflected upon the life beyond, are all shaped after models familiar upon the earth."

In the earlier stages of his career man was in utter ignorance of the nature of the earth. It is not too much

to say that these unknown elements can hardly be considered as being in his environment. Hence it follows that man's discoveries are constantly changing in a real sense the world in which he lives. It is one world when he knows a few of the properties of wood and stone. It is another when he discovers the metals, learns to use copper, tin, zinc, gold, silver, iron, and yesterday platinum and aluminum, today radium.

There can be no greater mistake than to think of the physical environment as fixed and unchanging, though that mistake is far from rare. Geology was once taught as if the earth were completed ages ago. As a matter of fact, it is changing as rapidly today as ever, so far as we can tell. The formation of rocks and their gradual disintegration under the influence of snow, rain and wind is still going on. Change, eternal change, is the one great fact in nature.

Our evidence shows that the physical contour of the earth has been greatly altered in the course of time. We know that the Appalachian Mountains are but the stumps left of a great range. We know that there were four (possibly five) glacial epochs when the ice sheet covered North America as far south as Pennsylvania and Missouri. Sometime during this period the Great Lakes came into existence. The cause of these epochs, their duration, their disappearance and their effect upon organic life are some of the most fascinating puzzles of history. Oceans now exist where once were dry land and mountain ranges, whose slopes were once ocean beaches.

It is evident too that the climate of any given area of the earth has often undergone tremendous changes. Iceland was once a subtropical country with a flora resembling that of Florida, rather than its own. All the country recently

labeled as the Great American Desert was once a moist, fertile land, densely populated by animals. Now these great herds are gone and the Great Salt Lake is but a puddle in comparison to its ancient self when it had an outlet to the Pacific. It appears that west Central Asia has been drying up throughout all recorded time. Huntington says: "If it be proved that the climate of any region has changed during historic times, it follows that the nature of the geographic provinces concerned must have been altered more or less. For example, among the human inhabitants of Central Asia widespread poverty, want and depression have been substituted for comparative competence, prosperity and contentment. Disorder, wars and migrations have arisen. Race has been caused to mix with race under new physical conditions, which have given rise to new habits and character. The impulse toward change and migration received in the vast arid regions of Central Asia has spread outward and involved all Europe in the confusion of the Dark Ages. And more than this, the changes of climate which affected Central Asia were not confined to that region apparently, but extended over a large part of the inhabited earth."[32] In 1911 and 1912 Huntington had opportunity to examine some 450 big trees of California which varied in age from 230 to 3200 years. Eighty were over 2000 years old. Judging from the width of the rings the sequoia grew on the average of 30 per cent faster at the time of Christ than it did A.D. 1500.[33] In our own arid southwest there are many evidences of an earlier civilization when large areas were cultivated both with and without irrigation. The Pimas call these people the Hohokam or "perished

[32] HUNTINGTON, E. The Pulse of Asia, pp. 15, 16.

[33] HUNTINGTON, E. *American Historical Review*, January, 1913.

ones." Mr. Huntington has recently made some most interesting studies in this country. Of the Santa Cruz Valley in New Mexico he writes: "The part of the valley which is now capable of cultivation contains ruins which indicate that all the available land was utilized in the past. Below the point where irrigation is now possible there are three large groups of ruins, and the three together must have had as many people as the higher regions where there is still water. In other words, it seems as if the Santa Cruz Valley once had at least twice as many people as it could at present support, and half of these lived where the white man could not now get a living from agriculture." [34]

The question over which scientists are now puzzling is whether these and other changes come in cycles. There are many who believe that there is a periodicity in the sun spots and, correspondingly, periods of greater evaporation and rainfall on earth. The decision must be left to the future.

Certain other changes are also clear. The rivers of the world are building great alluvial deltas out of the material taken from the hills. Thus through the ages the Mississippi has made its delta from Cairo, Illinois, to its present mouth. It annually carries to the sea 225,000 acre feet of fertile soil and builds new land for future men. That this process may involve serious loss to existing society is also evident.

Now all these changes, whether the yearly cycle of temperature, or the greater pulsations as they have been called, involve constant readjustments of life. Sudden changes are always most dangerous. Even change in food and drink may produce serious results. There are many

[34] HUNTINGTON, E. *Report of Smithsonian Institute*, 1912, p. 393.

small ponds and streams which occasionally go dry with great loss of life. Man prepares for the coming winter, but the earthquake, tidal wave or volcanic eruption finds him helpless. If the coal supply failed this year our civilization might easily perish. Realizing that at some period it will fail, our ingenuity may enable us to find some substitute. Tides, winds and sun rays will some day be valued sources of energy.

Against the minor changes of storm and frost man easily protects himself. Not so, however, the lower forms of life. Frost indeed simplifies man's problems by killing his insect pests. Winter in the colder regions destroys countless myriads of organisms. Some scheme of suspended animation as it were must be evolved if any are to survive. Nature is fertile in inventions. By means of roots, unaffected by freezing and seeds which lie on the ground and germinate the next year, she saves her plants. For the animals there are eggs to hatch the next year, larvæ to penetrate the earth, cocoons from which the new form comes, hibernation for bears, migration for birds, while every rotten log or hollow tree literally teems with dormant life.

"The animal lives in an environment which is constantly changing. Its spontaneous movements are constantly bringing it into different conditions. It tends to regulate its internal processes by selecting the point in the environment in which its internal processes are not disturbed." [35] The mollusca living in the tide lines must be small enough to find protection by creeping into crevices of the rocks unless, as is usually the case, they have a strong pedal sucker which enables them to remain fixed. The blood temperature of hibernating rodents

[35] SHELFORD, V. E. o. c., p. 29.

falls to about 40°, sometimes nearly to 35°. A little oxygen reaches them, but so little is required that immersion of an hour in carbon dioxid will not kill them. They must be fat when they begin the long sleep and must waken gradually. It is thought that if their temperature falls too low they awaken automatically, and by movement and the inhalation of oxygen again raise their temperature. The differences in the behavior of frogs in hot and cold water is interesting. In the former they are extremely lively, and as the temperature drops they become sluggish and drowsy.

Animals show marked powers of readaptation — to avoid the use of the word *reason* which some feel is a prerogative of the human. Our common chimney swifts once nested in hollow trees or crevices in the rock, but they accept chimneys as satisfactory substitutes. The black-throated hunting and other ground-building birds will, if their nests are destroyed, frequently build late in the season in trees. Ducks and geese that are hunted become extremely wary, but will quickly discover and frequent in large numbers a lake where shooting is prohibited. In parts of Africa because of the constant hunting the buffalo feeds only at night.

Even the daily changes are significant. Sleep results apparently from a drugging of the system by the carbon dioxid and other elements produced by everyday activity, which are less rapidly eliminated. At night, therefore, the eliminating process goes on till a balance is again secured. Possibly some structures are due to those daily changes. There is reason to believe that the barring of the feathers of some birds is due to the low blood pressure and poor circulation at night.

An interesting rhythm is shown by the phosphorescent

organisms of the sea. "It might be supposed at first thought that these phosphorescent organisms are not observed to emit light during the day because of the pressure of sunlight, and that if taken into a dark room they would be found to phosphoresce just as brilliantly as at night. Such is, however, not the case, not a spark can be elicited from them even by vigorous shaking, so long as there is daylight in the outer world. But if one stands by and watches in the dark room, as twilight is falling outside, although the organisms have been exposed to light all day, one observes the little lamps light up and flash out one by one like coruscating diamonds in the darkness till the whole fish is studded with flashing and disappearing light, a glorious sight in the darkness and stillness. . . . Regularly every evening the lights come out, and as regularly every morning they are extinguished, although all the intervening time the tiny living creatures have been kept in darkness." [36]

It should be noted that changes *within* the body may make a fixed environment act as a stimulus. Animals change in many ways when physical maturity is reached. Thus the queen ant remains quietly in the dark nest while young. On the advent of maturity she leaves the earth, flies toward the light and keeps away from the ground. When fertilized she again seeks the earth, burrows into it and starts a new colony.

The rhythm of nature can hardly fail to impress the observer. The revolution about the sun, the ebb and flow of the tides and the waves of light and sound illustrate rhythm in the purely material world. Birth, youth, maturity, old age and death, show the cycle of life. The alternating periods of rest and activity, the

[36] Moore, B. The Origin and Nature of Life, pp. 250–251.

pulsations of the heart and the inhalation and expiration of the breath display it in the activities of organisms. Whether such rhythm also characterizes human institutions must be considered elsewhere.

Against such changes as have come in western Asia even man is largely powerless unless he moves. He may invent new measures which enable him to survive, but more likely he starts his migrations. No wonder then that Huntington says: "Finally it appears that the changes of climate have caused corresponding changes, not only in the distribution of man, but in his occupations, habits and even character." [37]

It is not a matter of accident that the weather is the common basis of conversation the world over. Each and every primitive man came into close, daily, personal contact with nature. From this contact he had to get all the goods of everyday life. He was exposed to wind and storm. He saw the sun rise and set, the glory of the moon and stars. Now the civilized man has multiplied the contacts with nature in a sense he has weakened the force of each. His contact becomes more and more at second hand insofar as the great fundamentals are concerned. Hence he often ignores or denies even the great guiding forces sketched in this chapter. Yet in the qualities of the elements of the earth and man's adjustment thereto is the basis and start of all man's vaunted achievements as well as the limits thereof.

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## CHAPTER II

### MUTUAL AID AND THE STRUGGLE FOR EXISTENCE

We have seen that life exists because of the nature of the elements and that it continues to exist if the environment is favorable. We must now consider the various ways in which the different forms of life affect each other. The reader is warned not to interpret all the phenomena to be mentioned as if they resulted from some conscious purpose in the plants or animals. Most of the service rendered, or the harm done, results solely from the nature of the organisms. Thus plants produce purely mechanical effects of the utmost importance. By forming a dense sod they keep the soil on the hillsides from which otherwise it would quickly be removed by water. Their roots extend into the subsoil, then die and decay, thus making openings for air, water and frost which tend to break up the soil, to expose new particles of plant food and thus make increased vegetation possible.

Plants absorb a considerable part of the carbon dioxid given out by animals. Thus they help to make the air fit for animals to breathe just as in water they perform a similar service. They also take up large quantities of water from the earth which pass into the air through the leaves, the amount increasing as the temperature increases, diminishing as it falls. The Washington Elm at Cambridge, Massachusetts, was studied by Professor Pierce of Harvard. He reported that the tree bore some 7,000,000 leaves having a surface area of 200,000 square feet

or about five acres. It being estimated that one acre of grass furnishes 6,400 quarts of water in twenty-four hours, this tree supplied some 32,000 quarts of water daily. The influence of forests is very large. They reduce the mean temperature of the air, increase the humidity, decrease the violence of the winds, offer protection against very hot winds and regulate to some extent the flow-off of the water. Significant as these mechanical changes are they become as nothing when compared to the chemical changes produced by plants.

The common chemical elements found in plants are carbon, nitrogen, hydrogen and oxygen. Plants get the nitrogen and hydrogen largely from the soil, the carbon and oxygen from the air. Now there is very little nitrogen in the rocks, whereas it forms 80 per cent of the air. How is it, then, that cultivated soil contains from .1 per cent to .2 per cent nitrogen, while rich prairie soils have perhaps 25,000 pounds per acre in the top three or four feet? That the leguminous plants (clover, alfalfa, peas and beans) enriched the soil and increased the yield of other crops was known to the Romans of old. It was not until 1886 that Hellriegel was able to show that this was chiefly due to colonies of bacteria which collected in nodules on the roots and were able to draw the nitrogen directly from the air and make it available for plants. It is estimated that an acre of alfalfa adds nitrogen worth at least $25.00 per year to the soil. Most of this supply of nitrogen in the soil must have been taken from the air by earlier generations of bacteria.

Plant tissues contain much carbon. Forty per cent of the weight of rye straw is carbon. An acre of beech forest consumes almost a ton of carbon yearly. This must be

obtained from the carbon dioxid which forms some .04 per cent of the air. Under the influence of the sun, for the process takes place in the light only, plants are able through the green substance in their leaves called chlorophyll to appropriate this carbon and embody it in their tissues. No animals have this power unless we make an exception of a few lowly forms like the fresh water polyps, which carry within their bodies algae containing chlorophyll and thus need not wholly depend on an outside supply of proteids. Animals can directly utilize a few substances like salt in small amounts but their continued existence depends on the "predigested food" prepared by plants. The mere existence of animals then is conditioned on the existence of plants. Even the flesh-eating animals form no exception for "all flesh is grass" no matter how many intervening incarnations there may be.

In time the plants die and begin to decay. That is, their substance is used as food by many lowly forms of life and finally, by the joint efforts of different bacteria, are reduced to the simple forms which are again used as food by plants. This decayed vegetable matter we call humus and few plants prosper unless it is present in the soil. This breaking down process is rather complicated and no one sort of bacteria produces all the changes. The first step involves the decomposition of the proteids into ammonia. This is changed by bacterial action into nitrites, and these in turn by union with bases such as calcium and magnesium into nitrates and made available for plants. The nitrite and the nitrate forming bacteria exist side by side in the soil and work together. There are also other bacteria which are able to break down the nitrates and return the free nitrogen to the air. In a

sense then the bacteria in the soil may compete with the plants for food.

It is evident that these bacteria are performing services of the utmost importance and that the life of the higher forms would be impossible without them. They exist in the soil in incredible numbers, up to several million per gram, the greatest number being immediately below the surface. They are nature's scavengers destroying organic compounds. Some of them will live in ice water but the great mass develop at a temperature of 70°. The non-spore-bearing bacteria will perish in water at a temperature of 140° to 150° but the spore-bearing sorts will survive exposure to dry heat of 250° and boiling for an hour.

The proper decay of humus depends on the presence of lime and certain bacteria which draw phosphoric acid directly from the rocks. "In the presence of carbonate of lime and carbon dioxid the insoluble silicate of potash is gradually turned into carbonate of potash, and also into other compounds of the latter." [1] Bacteria aid also in the decomposition of sulphur and iron.

Organic compounds are exceedingly delicate and every one knows how difficult it is to keep them unchanged. We may dry the fruit or meat to such an extent that bacteria does it no harm, but ordinarily the apple or potato rots, the milk sours in spite of our utmost precautions. These changes may or may not be to our liking. Some of them we welcome, others we deplore. The souring of milk is due to a species of bacteria, but if other varieties are present we may have "blue milk," "ropy-milk," "red-milk," or "bitter-milk." By using certain bacteria and yeast we produce the sour milks known as

[1] LIPMAN, J. G. Bacteria in Relation to Country Life, p. 293 (most of statements relative to bacteria taken from this book).

"kefir," "kumiss" or "matzoon" which are considered of great value. The ripening of the cream is due to bacteria and the average number per c.c. of ripened cream is about 500,000,000. The change to butter and cheese is due to bacteria. We use the yeast plant in the making of bread. Hay is in part the result of bacterial action as is ensilage. So too bacteria are used in the retting of flax and hemp, the tanning of hides, the fermenting of tobacco, the manufacture of vinegar, wine and beer; in the making of pickled fish, sauerkraut and dill-pickles and in the purification of sewage.

Thus nature shows us a most fascinating cycle. The elements, taken from the earth or the air, are utilized to form the bodies of plants and animals and finally are returned to the earth to be used again. Thus the life that now is depends not merely on the coöperation of other forms of life, but also on the life that was. Paradoxically enough the greater the mass of life there is the greater the possible increase — other things being equal.

Some animals also help in preparing the earth for other and higher forms of life. The minute protozoa whose remains constitute our beds of chalk are not to be forgotten. The service of the coral polyp in building the islands on which man later lives is well known. In an acre of soil Darwin showed that there were from 50,000 to 500,000 earthworms, each of which passed through its body some 20 ounces of earth a year. On two square yards studied by Darwin the amount equaled 6.75 pounds and 8.38 pounds or at the rate of 14½ to 18 tons per acre per year. Working their way through the earth they open roads for roots and rain. The soil passing through their bodies is softened, and is cast on the surface at a rate estimated at three inches in fifteen years. They

carry leaves into the soil and thus aid in producing the humus. Thomson states that in Yorubaland on the west coast of Africa it is estimated that every particle of soil is brought to the surface once in twenty-seven years. Said Darwin: "It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures." [2] Ants and other insects perform similar services.

Another type of dependence must be noted. The digestive tract of all the higher animals is densely populated, from a few hours after birth till death by great numbers of micro-organisms. Says Herter: "There is not the least doubt that in some way — a rather intricate way — these normal and dominant flora of the intestine exert a protective action on the whole body. This protective action is complex in operation, but consists at least in part of a preëmptive effect on the intestinal domain, by which other types of bacteria are in large degree excluded. It is impossible to avoid introducing into the digestive tract many bacteria which would prove undesirable permanent tenants, and these are successfully discouraged from gaining a foothold by the motile biological activities of the more permanent and better adapted bacterial guests." [3] If the native flora are destroyed or injured "wild" types may be introduced and this Metchinikoff, one of the most eminent biologists, believed to be a common cause of suffering and premature death. This idea is not universally accepted, and many still believe this natural flora to be neutral in influence rather than helpful. With reference to other types we must recognize

[2] Thomson, J. A. Darwinism and Human Life, pp. 56–59.
[3] Herter, C. A. Biological Aspects of Human Problems, p. 130.

probably that living within our bodies, by their life and death many poisons are produced which are directly injurious to the body. From this standpoint health depends upon a nice adjustment between the natural defenses of the body and the attacks of the invaders. Some of the evil effects will be considered later.

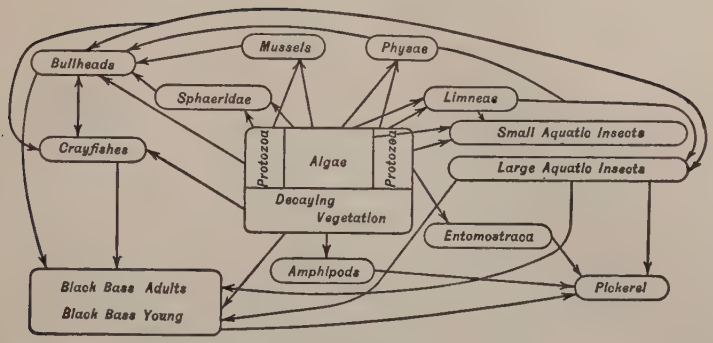
In the preceding chapter we saw that the presence of life in any area depended upon certain physical conditions. It must now be noted that the presence of any of the higher types of life depends also upon the presence of certain other types. In other words, there is a series of interrelations reaching from the lowest to the highest forms. Wherever conditions are favorable the mass of the lowest forms is almost beyond comprehension. I have seen a small pool in Mississippi containing much decaying matter so densely inhabited that the surface was kept in constant motion with a bubbling as of a small brook. To this aggregation of small plants and animals in water we give the collective name plankton. In Lake Michigan Shelford found 11.5 c.c. of this plankton in each cubic meter of water. He states that if the inhabitants of Chicago drink daily 2,000,000 quarts of unfiltered water they imbibe therewith ten solid quarts of plants and animals. He reports that in some of the European lakes ten times this amount is found. In the Illinois River 71.36 c.c. were found, and in an Indiana lake 684 c.c. The largest amount was present from April to June, the least in December and January.[4] The abundance of plant growth depends upon the amount of all the necessary foodstuffs. If any one is absent growth is stopped. As a rule the older and quieter the body of water the greater the plant life. Within certain limits this is also true of animal life. The

[4] SHELFORD, V. E. o. c., p. 67.

oldest pond may show an excess of carbon dioxid or too little oxygen, or offer no good breeding place for many species of fish. In such ponds the relations of animals and plants are most interesting. Floating plants gather on the stems of the larger rooted varieties. Hither come snails and other animals seeking food. They too attach themselves to the stems or leaves finding there protection against currents, shelter from excessive light and opportunities for laying their eggs. Some indeed depend more directly upon plants. Certain leaf-eating beetles are aquatic in their early stages. They have no gills, but attach themselves to plants from which they get a direct supply of oxygen even under the water.

So many and so varied are the interrelations between the highest and the lowest forms of life that it is impossible to exaggerate them and almost impossible for one not a close student of zoölogy to realize their extent and significance. Volumes of illustrations could be given. Here space permits reference only to a few of the different types of relationship. Under the title "ecology" great attention is now being given to this study of community life, particularly of animals. It is believed that, under similar conditions the world over, there will be found animals not necessarily the same, but filling the same niches in the scheme.

In the world of water crustaceans are the most important invertebrates, "the entomostraca being from the standpoint of food supply to the water what rooted plants are on the land, one of the things to which food interaction can be traced." This food dependence is well shown by Shelford in the following diagram.




FOOD RELATIONS OF AQUATIC ANIMALS. ARROWS POINT FROM ORGANISMS EATEN TO THOSE DOING THE EATING

"Let us assume that because of some unfavorable conditions in a pond during their breeding period the black bass decreased markedly. The pickerel, which devour young bass, must feed more extensively upon insects. The decreased number of black bass would relieve the drain upon the crayfishes, which are eaten by bass; crayfishes would accordingly increase and prey more heavily upon the aquatic insects. This combined attack of pickerel and crayfishes would cause insects to decrease and the number of pickerel would fall away because of the decreased food supply. Meanwhile the bullheads, which are general feeders and which devour aquatic insects, might feed more extensively upon mollusks because of the decrease of the former, but would probably decrease also because of the falling off of their main article of diet. We may thus reasonably assume that the black bass would recover its numbers because of the decrease of pickerel and bullheads, the enemies of its young." [5]

The great advantage which animals have over plants as regards food grows out of their power of motion. If

[5] SHELFORD, V. E. o. c., p. 70.

the supply is inadequate in one place they may go in search of another, though it is to be recognized that the search is not always successful.

In return for the contributions made by plants to animals, the latter often perform services of highest importance to plants. Chief of these is perhaps the fertilizing of the flowers. Many varieties produce on one plant flowers having only pistils or stamens, and the pollen must be carried either by the wind or by insects. Other flowers are so shaped that only by some outside agency can the pollen reach the pistil even though both are present. The fig has its flowers inside a tube into which certain insects must crawl. Every one has watched the bees gathering honey in the flowers and incidentally and unwittingly getting on their bodies pollen which they carry to other plants and thus cross-fertilize them. Without such co-operation many species would perish. Thomson in happy fashion enlarges one of Darwin's illustrations: "'Plants and animals remote in the scale of nature are bound together by a web of complex relations. . . . I have also found that the visits of bees are necessary for the fertilization of some kinds of clover,— thus 100 heads of red clover (*Trifolium pratense*) produced 27,000 seeds, but the same number of protected heads produced not a single seed. Humble bees alone visit red clover, as other bees cannot reach the nectar. . . . We know that the red clover imported to New Zealand did not bear fertile seeds till humble bees were also imported. The number of humble bees in any district depends in great measure on the number of field mice which destroy their combs and nests; and Colonel Newman, who has long attended to the habits of humble bees, believes that more than two-thirds of them are thus destroyed all over England.' Now the

number of mice is largely dependent, as every one knows, on the number of cats; and Colonel Newman says: 'Near villages and small towns I have found the nests of humble bees more numerous than elsewhere and this I attribute to the number of cats that destroy the mice.' Thus we may say with Darwin that next year's crop of purple clover is influenced by the number of humble bees in the district, which varies with the number of field mice, that is to say, with the number of cats." [6] This involves a tremendous amount of labor. A red clover blossom contains less than one-eighth grain of sugar. There are 7,000 grains in a pound. The bee must visit some 56,000 clover heads inserting its proboscis into some 60 florets on each head thus repeating the operation 3,360,000 times to get a pound of honey.

"More than two thousand years ago Herodotus observed a curious custom in Egypt. At a certain season of the year, the Egyptians went into the desert, cut off branches from the wild palms, and bringing them back to their gardens, waved them over the flowers of the date-palm. Why they performed this ceremony they did not know; but they knew that if they neglected it, the date crop would be poor or wholly lost. Herodotus offers the quaint explanation that along with these branches there came from the desert certain flies possessed of a 'vivific virtue' which somehow lent an exuberant fertility to the dates. But the true rationale of the incantation is now explained. Palm trees, like human beings, are male and female. The garden plants, the date bearers, were females; the desert plants were males; and the waving of the branches over the females meant the transference of the fertilizing pollen dust from the one to the other." [7]

[6] THOMSON, J. A. o. c., p. 53.

[7] DRUMMOND, HENRY. Ascent of Man, p. 242.

Animals assist greatly in the spread of plants and trees. Along the fence rows appear cherries, sumac, dogwood and junipers whose seeds have been deposited by birds. Squirrels often carry walnuts, chestnuts and acorns considerable distances. Many seeds like burdock or cockleburs catch in the hair of passing animals and are thus transported to new locations.

Every observer has in spring time watched the ants crawling over the buds of flowers and at first doubtless feared lest they do them damage. Closer study shows that the ants are seeking the aphids or plant lice from whose bodies they get a drop of liquid of which they appear very fond, sometimes stroking and caressing the aphid to stimulate the production of the fluid. Hence aphids have been called the slaves or the "cows," as Linnæus names them, of the ants. In any case they directly furnish food or some acceptable stimulant.

The complex social life of bees and ants is so often described that any extended account is unnecessary. It is worth while to indicate some of their methods, however, which vary greatly according to the species. The Amazon ant "exists only by the capture of slaves and in that connection develops the most brilliant warrior talent that we know in the entire animal kingdom. Its mandibles are modified to be solely weapons for killing and are unsuited for domestic occupations; furthermore it has even lost the instinct of feeding by itself and must be fed out of the mouths of its slaves." Wasmann estimates that some 2,000 species of animals are found in association with ants, some as guests, some as slaves, others as parasites. Some beetles "are not only licked by their hosts (first step), but are also fed regularly from their mouths (second step), and finally also the larvæ of these

beetles are reared by the ants like their own brood (third step)." In the long run, this leads to the destruction of the ant colony. "Certain native ants even keep the eggs of plant lice with their nests during the winter. The sanguinary robber ant occupies herself almost exclusively with hunting, and leaves the cultivation of plant lice to her slaves." The hunting ants of Africa are accompanied on their forage by "a host of guests, particularly of the family of the short-winged beetles." Other ants make web nests using their own larvae as shuttles. "They conduct the mouth of the larva, from which the spinning substance issues, from one leaf margin to another, and thus weave their nest." [8]

A different type of coöperation is seen in the habits of such birds as cowbirds in America or the herons which accompany the herds of buffalo in Africa. Here these companions either feed on the parasites of their four-footed friends or take advantage of the insects attracted by their presence or disturbed by their movements through the grass.

Curious indeed are many of these relationships. Certain of the minute mussels attach themselves temporarily to some fresh water fish like the minnow, later dropping off far from the starting point; while perhaps, to reverse the relationship, the young — of one fish at least, the bitterling, are for a time parasites in the gills of a mussel.[9] A more direct dependence exists in the case of the parasites which infest the fur or feathers of large animals. All birds and mammals continually carry with them such insects as lice, fleas and ticks, which draw their nourishment from their unwilling hosts. Though this process

[8] *Annual Report of Smithsonian Institute*, 1912, p. 455.

[9] THOMPSON, J. A. o. c., p. 55.

is often irritating the burden is usually small, save when the parasites are the carriers of disease. Even man himself is rarely free from such companions until he reaches a relatively high standard of personal cleanliness while the lower ranks of society are continually infested. To this parasitic class belong a few forms of plant life such as the fungus producing the disease known as thrush.

Much more serious on the whole from the standpoint of the welfare of the invaded organism are the internal parasites, whether plant or animal. These are now recognized as the causes of some of the chief diseases to which flesh is heir. The story of man's attempt to conquer these invaders will be told in the next chapter. Here the fact must be noted and its significance indicated. These parasites vary in size from the minute one-celled forms — some of which are probably too small to be seen with the strongest microscopes; some that we have not yet isolated, although the results of their presence are only too well known — to the great tapeworm which occasionally dwells in our intestines. We know three forms of the bacteria, of which the smallest are the cocci, some 1/150,000 of an inch in diameter. The rodlike forms (bacilli) are from 1/25,000 to 1/4,000 of an inch in length by 1/125,000 to 1/6,000 of an inch in diameter; while the largest spirilli are about 1/600 of an inch in length. One drop of sour milk may contain 40,000,000 bacteria. Some of these are never found in man but are common among animals as, for instance, the cholera of chickens; others, like measles, chicken-pox and typhus fever so far as we know are peculiar to man; while many others, diphtheria, tuberculosis and anthrax are common to man and animals. We now know that some organisms like those causing malaria and yellow fever pass one part of their life cycle

in the bodies of the mosquito or other insects and by them are transferred to man. In all such cases, the lower forms of life live at the expense of the higher forms and not infrequently destroy them. Plants parasitic upon others — as the mistletoe on the oak — are also common.

The illustrations already given make it clear that this series of relationships has many sides and may be considered from several viewpoints. The relations of the bee and the clover are mutually advantageous. The dog carrying the cocklebur performs an unrequited service. From the standpoint of the mouse his relations to the cat are decidedly one-sided, and man is far from pleased at being the host of disease germs. Now these two aspects of the "web of life" may be called "mutual aid," or coöperation, and "the struggle for existence," or competition; both of which are of such tremendous significance to the student of life, though in the last century the emphasis on the latter phase has largely obscured the existence of the former. We thus have a paradox. Life depends upon life and this involves the destruction of life.

Communities rather than isolated individuals are characteristic of animals. Plant associations are accidental rather than voluntary, but animals seem to prefer the presence of their fellows. "Whether the feeling be fear, experienced at the appearance of a bird of prey, or a 'fit of gladness,' which bursts out when the animals are in good health and especially when young, or merely the desire of giving play to an excess of impressions and vital power — the necessity of communicating impressions, of playing, of chattering, or of simply feeling the proximity of other kindred living beings pervades Nature, and is as much as any other physiological function, a distinctive

feature of life and impression ability. This need takes a higher development and attains a more beautiful expression in mammals, especially amidst their young, and still more among the birds; but it pervades all Nature." [10]

Whenever man has entered a relatively unpopulated continent where conditions were favorable he has been amazed at the abundance of wild life. "I found the Cossacks in the villages of that gorge in the greatest excitement because thousands and thousands of fallow deer were crossing the Amur where it is narrowest in order to make the lowlands." [11] "For several hundred yards from the shore the air is filled with gulls and terns, as with snowflakes on a winter day. Thousands of plover and sand coursers run over the beach, searching for their food, whistling and simply enjoying life. Further on, on almost each wave, a duck is rocking, while higher up you notice the flocks of the Casarki ducks. Exuberant life swarms everywhere." [12]

Men now living can recall the enormous herds of bison that roamed the Western prairies, the passenger pigeons whose vast flocks almost darkened the sun and broke the branches of the trees on which they settled or the armies of squirrels. In the far north the caribou still migrate in companies of thousands. Though of a younger generation, the writer has been privileged to see some of the rocky islands so densely covered with birds that one thought the surface moved when they took wing. He has seen prairie chickens leaving the wheat stubble of Dakota by the hundreds and has watched in early spring great companies engaged in lovemaking. Birds ordinarily considered as rather solitary often combine in large flocks.

[10] Kropotkin, P. Mutual Aid, p. 55.
[11] Ibid., p. 48.
[12] Ibid., p. 33.

The great winter flocks of crows going to and from their roosting places to the feeding grounds are common sights. I have witnessed some remarkable flights of hawks when for several consecutive days individuals of many species drifted lazily by, scores being constantly in sight. I have known the short-eared owls to gather in large companies. Blind indeed is he who has not viewed with wonder the migrations of the birds in spring and fall. Who has not awakened some spring morning to find the fields and woods full of a variety of birds of which a day before only a few could be found? Who has not been thrilled by the melody of the bobolink or admired the formal columns of the geese? These migrating groups are often of very distinct species. Eight kites, one crane and one peregrine falcon are reported as forming one motley group.

It must not be thought that these are always chance associations. There are many illustrations of a definite purpose. Pelicans "always go fishing in numerous bands and after having chosen an appropriate bay, they form a wide half-circle in face of the shore, and narrow it by paddling towards the shore, catching all the fish that happen to be inclosed in the circle. On narrow rivers and canals they even divide into two parties, each of which draws up on a half-circle, and both paddle to meet each other, just as if two parties of men dragging two long nets should advance to capture all fish taken between the nets when both parties come to meet." [13] Hunting parties of animals are well known. Monkeys combine to get food. Brazilian kites are said to summon assistance if the prey is too large. Kingbirds frequently combine to chase a crow or hawk. If a burying beetle discovers a dead mouse it summons from four to ten others to help. Crabs have

[13] KROPOTKIN, P. o. c., p. 23.

been known to work for hours to try to help a comrade that had been put on its back.

In our climate birds scatter somewhat during the mating season. Later, flocks of young birds may be seen gaining strength by many flights ere they join in larger and larger companies for the southward journey which takes many of them even to South America. There must be some advantage in these associations. Our prairie dogs might live so far as conditions are concerned scattered over the plains; instead they live in great villages. Possibly this lies in the strength of numbers and the better chances of protection. Many birds such as cranes or parrots post sentries while the flock is feeding or send out spies to make sure no enemy is about; they live, save during the breeding season, in flocks; they have common roosting places; they combine against enemies. As a result, they reach a considerable age and have few large enemies save man.

The great power gotten by bees and ants as a result of their social habits and division of labor is often described. Observers in Africa tell of the warlike ants driving all animals before them on their marches.

Now it is to be noted that among those of any given species there is little direct competition but rather vast coöperation. The warning against common enemies; the care, often the joint care of the young; the many efforts to assist the injured and the combination to fight the intruder are all opposed to purely selfish considerations. Save where sex enters in they rarely fight each other. No wonder then that Kropotkin writes after viewing these animal societies: "As seen from the above, the war of each against all is not the law of nature. Mutual aid is as much a law as mutual struggle." [14] Or again: "'Don't

[14] KROPOTKIN, P. o. c., p. 22.

compete! — competition is always injurious to the species, and you have plenty of resources to avoid it.' . . . That is the watchword which comes to us from the bush, the forest, the river, the ocean. 'Therefore combine — practice mutual aid.' . . . That is what Nature teaches us, and that is what all those animals which have attained the highest positions in their respective classes have done." [15]

There are, to be sure, illustrations of solitary specimens of social animals — rogue buffalo, rogue elephant — which seem to have been driven out of their groups. There are some animals among the carnivora which seldom associate save in very small groups. There are a few like the gorilla rarely seen save in family associations or alone. These are extremely exceptional and perchance are but the few survivors of groups once gregarious. From fish or insects, through the great bird and mammalian groups, to man himself, association and the resulting coöperation are well nigh universal.

There is another side to the picture more striking and spectacular, hence better known. Inasmuch as it is one of the functions of life to furnish food to other forms and inasmuch as the willingness to be eaten is seldom synchronous with the hunger of the eater, there is a constant warfare. Strength, cunning, fleetness of wing or foot or the maintenance of group life may enable the individual to survive. Sooner or later there is likely to come the accident or sickness, the weakness following absence of food, the moment of inattention and the enemy has done his work. It may be true that the great bulk of lives lost are those of the young and untrained; it may be that sudden temperature changes may reduce thousands to

[15] KROPOTKIN, P. o. c., p. 75.

scores; but it still remains true that the destruction by other types of life is *in addition* to that wrought by physical changes. The combined results are enormous. Natural death, in the sense we use the term (death from old age), is the least common form in the animal world. Well may Roosevelt say: "Civilized man now usually passes his life under conditions which eliminate the intensity of terror felt by his ancestors when death by violence was their normal end, and threatened them during every hour of the day and night. It is only in nightmares that the average dweller in civilized countries now undergoes the hideous horror which was the regular and frequent portion of his ages-vanished forefathers, and which is still an everyday incident in the lives of most wild creatures. . . .

"Death by violence, death by cold, death by starvation — these are the normal endings of the stately and beautiful creatures of the wilderness. The sentimentalists who prattle about the peaceful life of nature do not realize its utter mercilessness; although all they would have to do would be to look at the birds in the winter's woods, or even at the insects on a cold morning or cold evening." [16]

On the whole, the lowest forms of life reproduce most rapidly, the highest the most slowly. The cholera bacillus can divide every twenty minutes, and might thus in one day become 5,000,000,000,000,000,000,000 with an estimated weight of about 7,366 tons. An annual plant with only two seeds would be represented by 1,048,576 in the twenty-first year. The descendants of a pair of house flies from April to November might amount to 214,577,844,320,000,000,000,000, while the young of a single pair of

[16] Roosevelt, T. African Game Trails, pp. 200–201.

mosquitoes in 180 days would be represented by the figure 2 at the left of one of these lines followed by a full row of ciphers. A pair of robins having four young each season and these reproducing in like measure would have some 20,913,948,846 descendants at the end of twenty years. The slowest breeder known, the elephant, if given a life of 100 years with an average of ten offspring which reproduced equally would have some 19,000,000 descendants in 150 years. Now, in actual life, no such reproduction takes place. We must recognize then the rapid possible increase, theoretically speaking, of the individual organism and also the relatively fixed total aggregate of any species. "If all the feeders on vegetable life were allowed to develop absolutely without check during two successive years, the first of them would see every green thing swept from the face of the earth, and the second would destroy all possibility of the future recurrence of fully 90 per cent of all the existing plants. . . . Under normal conditions, and in the long run, one pair of moths, producing say 500 eggs, are represented next year by another pair of the same species, and no more: that is, out of 500 eggs, producing 500 caterpillars, 498 are destroyed in some way. . . . The important thing is that a species abundant in number of specimens has become so in spite of the combination of all its natural checks and, conditions remaining equal, will maintain itself in the same ratio, just as a rare species barely maintains itself against the combination opposing it."[17] These checks are weather, disease, animals, birds and predatory and parasitic insects. "In this way it happens that after a season of grasshopper abundance a season of blister beetle

[17] SMITH, J. B. Our Insect Friends and Enemies, pp. 84–85.

abundance is almost certain to follow, and any abnormal increase of the former is almost sure to be checked by the corresponding increase of the latter." [18]

In other words, neglecting the tremendous destruction of life through failure to develop, whatever be the reason, and the frightful death-rate through storm or other natural agency, the fact that all life depends in large measure on other life for maintenance establishes what may be called the "balance of nature." In reality we have then an equilibrium which may be temporarily upset by any change in the conditions of life: thus giving now to one group of organisms, now to another, a peculiarly favorable chance for increase; but at the same time setting the bounds to this increase and providing the basis for the reaction.

It will not be specially difficult to understand this phenomenon if we can avoid the temptation to think of this struggle for existence as a *conscious* activity on the part of living organisms. Even man's actions are far less deliberate than we usually think. The effort to preserve individual life and that of reproducing its kind both growing out of the nature of self is the keynote. Under favorable conditions there will be both growth and reproduction.

The increase of any type of animal is conditioned in part upon the available food supply. Here man unwillingly and often unwittingly acts as host. He plants his crops but receives undesired coöperation in the harvesting thereof.

The Year Book of the Department of Agriculture, 1904, estimates the damage done yearly by insect pests to the various crops in the United States as follows:

[18] SMITH, J. B. o. c., p. 100.

| *Crop* | *Percentage of loss* | *Total amount lost* |
|---|---|---|
| Cereals | 10 | $200,000,000 |
| Hay | 10 | 53,000,000 |
| Cotton | 10 | 60,000,000 |
| Tobacco | 10 | 5,300,000 |
| Truck crops | 20 | 53,000,000 |
| Sugars | 10 | 5,000,000 |
| Fruits | 20 | 27,000,000 |
| Farm forests | 10 | 11,000,000 |
| Animal products | 10 | 175,000,000 |
| Miscellaneous crops | 10 | 5,800,000 |
| Total | | $595,100,000 |
| Natural forests and forest products | | 100,000,000 |
| Products in storage | | 100,000,000 |
| Grand total | | $795,100,000 [19] |

Insects are the most numerous of all the animal species. In spite of their vast number perhaps not more than five per cent do any great harm to the farmer, yet the burden is terrific. In 1894 there appeared in the southern counties of Texas a small beetle-like animal known as the boll weevil. It takes but fourteen days to develop from egg to adult and the progeny of a single pair may reach in a season 134 million. For some years it attracted little attention but, as was later discovered, kept spreading to the extent of some fifty miles a year. By 1912 it had crossed the Mississippi River, by 1915 had reached Georgia, and it is certain now to spread throughout the entire cotton-growing South. It feeds on the cotton bolls, the eggs being deposited in the unripe boll which is destroyed as the insect develops. It hibernates in cotton stalks or other plants. By 1903 it was thought that the damage done to the Texas cotton crop was some $15,000,000, but this was a wet season and particularly favorable to the weevil. Suffice it to say that in this immigrant the cotton planter finds his greatest enemy, and as yet no

[19] Year Book of Department of Agriculture, 1904, p. 464.

enemy has been found to check it. The natural enemy of the weevil in its own home, an ant, apparently will not live in our country, hence the plague. The total loss charged to its account down to 1914 is some $500,000,000 or 10,000,000 bales of cotton. Seven Mississippi counties in 1907 produced 171,790 bales. The boll weevil entered and the production in 1909 was 89,577 bales; in 1910, 61,432; 1911, 37,816, and in 1912, 30,909.

The larvæ of the corn-root worm feed upon the roots of young corn and sometimes cause the loss of the entire field. This worm and a few similar species probably destroy two per cent of the crop year by year. The ear worm eats the kernels — particularly of sweet corn of which some 90 per cent of the ears are attacked — and destroys not less than two per cent of the entire crop. Another two per cent goes to the chinch-bug. About fifty species of insects attack the corn and, in addition to the work of the three mentioned, probably reduce the crop another two per cent, making a total of eight per cent of the entire crop.

Of the cereals wheat suffers most. The Hessian fly, chinch-bug and grain louse are its worst enemies. In some years over one-half of the acreage planted has been abandoned because of the Hessian fly alone. In 1900 Indiana and Ohio are estimated to have lost not less than $24,000,000 on account of this pest.

The productiveness of the apple tree is reduced 5 per cent by the woolly aphis which attacks its roots, 2 per cent by the borers, and 10 per cent by the plant lice, scale insects and those that destroy the leaves. The codling moth, which lays its eggs in the young fruit through the country at large, causes a loss of not less than 20 per cent of marketable apples, while some estimates place the

loss at 40 per cent. Add to this loss the $8,250,000 spent yearly for spraying and the codling moth has caused us a loss of nearly $20,000,000 yearly.

The damage to stored products is greater than is realized. Tobacco, truck crops and cereals are attacked by worms, beetles, weevils and moths. The food waiting consumption at the house is visited by larder and ham beetles, various flies and moths.

Mr. Marlatt is then justified in his statement: "The losses resulting from the depredations of insects on all the plant products of the soil, both in their growing and in their stored state, together with those of live stock, exceed the entire expenditures of the National Government, including the enormous pension roll and the maintenance of the Army and Navy." The damage done to domestic animals by such insects as gadflies, botflies, screw-worm flies, ticks and lice is put at $175,000,000 yearly.[20]

We must also keep in mind the enormous burden imposed upon agriculturists by the growth of weeds, the yearly loss in the United States being estimated at $100,000,000. Weeds affect agriculture in many ways. If plowed under they may furnish humus and thus be valuable. When growing in cultivated fields, however, they are injurious. They may form a dense mat on the ground which holds moisture, invites insects and may introduce disease. In other cases they may use water needed for crops. If it takes several hundred pounds of water to produce one pound of dry stalks the loss may be serious for the crop. Furthermore, weeds may appropriate a considerable part of the plant food in the soil and finally they may smother the crop by their dense rank growth. The wild plants, native or introduced, frequently

[20] Year Book of Department of Agriculture, 1904, p. 461 ff.

show such virility that their destruction is extremely difficult. Whenever man plows a field and plants his crop, he destroys thereby the bulk of the native flora. Now it may be that some one or two species are so persistent that they find the new conditions with the soil mellow and only the cultivated plants as competitors most favorable, and develop to the extent of occupying the ground and balking the farmer's hopes. In the Eastern states this frequently takes place whenever the native honeysuckle starts in a grass field. Even more common perhaps is the introduction of some new plant, frequently with the seed of the desired species. A very large part of the weeds in our country have been introduced from Europe. Chickweed, dandelion, plantain, Canada thistle and burdock are a few which every farmer knows. Gray's Botany of 1887 listed 2,893 species of native plants and 405 introduced — a goodly percentage of the latter must be classed as weeds. Weeds, incidentally, are plants for which we have no use, or are useful plants growing where they are not wanted. In the South, Johnson grass, a species of sorghum, is one of the most valuable fodder plants. In a cultivated field it is however the despair of the planter.

Man engages therefore in a ceaseless warfare to protect his plants and insure crops. He must move his strawberry bed every year or two, not alone because of the rapid increase of the plants, but because of the growth of grass; he must change his hayfields, not merely for the sake of rotating crops, but chiefly to get rid of the weeds. The expert tells from the weeds on a farm the grade of the farmer. To keep undesired species from growing is thus a very important part of agriculture.

Animals have food preferences, but what they actually

eat is often more or less a matter of chance or necessity. It is interesting to note that the alimentary canal in carnivora is from three to five times as long as the body, while in herbivora it is from eleven to twenty-six times as long as the body. The fact that in man it is but seven times the body length may indicate that he is likely to cling to a meat diet.

Fortunately for man seeds and insects are the chief food supply of many animals, especially the birds. Some one-seventh of our birds are primarily seed eaters. The great family of finches and sparrows find seventy-five per cent of their food in seeds of weeds. The proven record of the bob-white is amazing.

*Number of Seeds Eaten by a Bob-white in One Day*

| | | | | | |
|---|---|---|---|---|---|
| Barnyard grass | 2,500 | rose ..... | 10,000 | Plantain ..... | 12,500 |
| Beggar ticks.. | 1,400 | Lamb's quar- | | Round-headed | |
| Black mustard | 2,500 | ters ..... | 15,000 | bush clover. | 1,800 |
| Burdock ..... | 600 | Milkweed .... | 770 | Smartweed ... | 2,250 |
| Crab grass ... | 2,000 | Peppergrass .. | 2,400 | Water smart- | |
| Curled dock .. | 4,175 | Pigweed ..... | 12,000 | weed ..... | 2,000 |
| Dodder ..... | 1,560 | Rabbit-foot | | White vervain | 18,750 |
| Evening prim- | | clover ..... | 30,000 | | |

One hundred and twenty-nine different weeds are known to furnish food to the bob-white. "In *Bulletin No. 21, Biological Survey,* it is calculated that if in Virginia and North Carolina there are four bob-whites to every square mile, and if each bird consumes one ounce of seed per day, the total destruction to weed seeds from September 1st to April 30th in those states alone will be 1,341 tons." [21]

Bob-white is partial to insects also. It is known to eat 145 species including such harmful varieties as the Colorado potato beetle, chinch-bug, wireworm, May beetle,

[21] HORNADAY, W. T. Our Vanishing Wild Life, p. 220.

squash beetle, cotton boll weevil, cutworm, codling moth and Hessian fly.

Taking the year as a whole, 73 per cent of the meadow lark's food is insects, 12 per cent weed seeds, 5 per cent grain. The crow blackbird eats insects 26.9 per cent; other animal food, 3.4 per cent; corn, 37.2 per cent; oats, 2.9 per cent; wheat, 4.8 per cent; other grain, 1.6 per cent; fruit, 5 per cent and weed seeds and mast, 18.2 per cent. The robin's diet consists of insects, 40 per cent; wild fruits, 43 per cent; cultivated fruit, 8 per cent; vegetables, 5 per cent. The fly-catchers feed almost wholly upon insects, while the great army of warblers are not far behind — 95 per cent. Over 65 per cent of the food of woodpeckers is insects. A fair breakfast for a mourning dove is put at three thousand grass seeds. The song sparrow will eat some 1,500 larvæ a day, while the yellow-throated warbler will consume 10,000 tree lice in the same time. A scarlet tanager has been known to devour 35 gypsy moths a minute for 18 minutes. More than 50 different species feed upon caterpillars, while 38 species live largely on plant lice. Five hundred mosquitoes have been found in the crop of one night hawk. Thirty-six species of birds feed on the codling moth, chief of which are woodpeckers, titmice and sparrows, in some places destroying from 66 to 85 per cent of the larvae. The great group of snipe, sandpipers and plover eat beetles, weevils, worms, mosquitoes and grasshoppers. The swallows are the greatest enemies in this country of the cotton boll weevil. It is claimed that in the state of Iowa there are about 89,000,000 birds, each of which eats not less than 25 insects per day, or a daily total of 2,240,000,000 or about 18,666 bushels of insects each day for the 150 days of the warmer months.

The relation of other animals to man must be considered. In the United States the most harmful animals are rabbits, rats and mice. In an Iowa nursery, over 3,000 trees were girdled in one season by rabbits; in a Maryland nursery, 2,000 out of 4,000 apple trees were ruined. It has been estimated that there are at least 300,000,000 rats in the country and that the damage done by them can not be less than $360,000,000 yearly, of which $100,000,000 is for grain consumed. In addition, we must consider the harm they do as disease carriers. Save as scavengers in the city, rats and mice are of no value.

Mice alone are responsible for a loss of $3,000,000 yearly in the United States. Short-tailed field-mice appeared in great numbers on the Humboldt River in Nevada in 1907 and by November there were from 8,000 to 12,000 per acre, their holes numbering about 24,000 per acre. During the summer they ruined one-third of the alfalfa, totally destroying many fields, 15,000 out of 20,000 acres having to be replanted. They destroyed three-fourths of the potatoes, badly damaged the remainder and severely injured beets and carrots. They girdled and killed most of the young shade trees planted along the irrigating ditches and about the fields. A conservative estimate of the losses in this district was $250,000. There were attracted to these fields probably 2,000 predaceous birds (hawks, owls, gulls, crows, ravens and herons) and 1,000 carnivorous mammals (skunks, weasels and badgers), which ate perhaps 45,000 mice a day or 1,350,000 a month. It seems that the mice had greatly increased for a couple of years, then came the year of greatest abundance and thereafter the numbers rapidly decreased. It is suspected that some disease was responsible to a large ex-

tent for the sudden decrease, but this is not definitely known.[22]

The mention of the predaceous birds indicates that they too may help man in the conflict with his foes. What can be said for hawks and owls? Professor Surface tells of a Pennsylvania experiment. The State put a bounty of fifty cents on every hawk or owl killed, and allowed twenty-five cents additional to the official making the affidavit, on the theory that chickens needed protection. In eighteen months the State paid out some $90,000. Assuming that 5,000 chickens were killed annually by these birds (though the truth is that they destroyed very few) and valuing those killed at twenty-five cents each, for many were very young, the total loss was $1,875. Most of this loss would have been prevented had the chickens been properly protected. Estimating the harm done by the mice, etc., that would have been killed by these birds at two cents apiece, these birds were worth $30 apiece to the State for eighteen months. 128,571 birds were killed, so that the State taxed itself some $3,857,130 plus the bounty paid, $90,000, a total of $3,947,130 to offset an estimated damage of $1,875. The mice increased so fast that the law was soon repealed.[23]

The Department of Agriculture places the owl among the most beneficial of all birds; rats, mice and rabbits being among their staple foods. At least 65 per cent of the foods of the red shouldered hawk consists of injurious mammals, and yet this is one of the hawks commonly called "hen-hawks." All hawks with one or two possible exceptions do some good — only six out of seventy-three species are listed as on the whole harmful — most of them

[22] Year Book of Department of Agriculture, 1908, p. 301.

[23] *Bulletin*, Pennsylvania Division of Zoölogy, Vol. I, No. 6.

doing vastly more good than harm. Even the crow, aside from some damage at corn-planting time and some destruction of nests of other birds, is the farmer's friend, eating great quantities of cutworms. On the whole the case for the birds is clear.[24] Once in a while a given bird or animal of a species, usually harmless, develops bad habits and must be killed.

Many other animals render assistance by no means inconsiderable. The despised skunk is one of the farmer's best friends. Foxes feed largely on mice as do weasels, though when the latter reach the chicken coop there is trouble. Coons eat insects as well as corn, and are rarely numerous enough to be important. The bats are entirely insectivorous and are of great value. Moles feed entirely upon insects and worms, the damage attributed to them by the gardeners being really done by mice which use their runs, though moles sometimes work havoc in a lawn. Porcupines live on the bark of trees and do some harm thereby. The woodchucks do considerable damage to crops, but are not abundant. Squirrels feed on insects as well as nuts. Practically speaking little damage is done then save by rats and mice, though in the districts where prairie dogs or gophers abound much injury is suffered by the grain crops. Most of the depredations of other animals could be prevented by better care of stock.

There is no better illustration of the way man's reason is upset by his prejudice than his attitude towards reptiles, particularly snakes. In the United States, outside of a few restricted localities inhabited by crocodiles, or parts of the desert southwest where lives the largest lizard we have, the Gila monster, whose bite is reputed to be poisonous, there are no legged reptiles which do man any harm.

[24] Fisher, A. K. Hawks and Owls of the United States.

The poor serpent continues to pay the penalty for Eve's temptation, while tradition combined with popular education inculcates a fear which is rarely deserved. Barring the moccasin, copperhead and rattlesnake, whose bites are very poisonous, there need be no fear. Moreover even where these snakes exist the actual danger is small, as they seldom voluntarily attack man. Incessant warfare has gradually exterminated them till now in the East and Middle West where rattlers once were very common, they are seldom found. There are still copperheads and moccasins in the East and South where hills, forests or swamps abound, and they should be killed whenever found. Elsewhere on earth other conditions sometimes prevail as in India where the foolish taboo on killing snakes causes the loss of some 50,000 lives a year. The smaller snakes feed largely on insects, larvae and slugs, while the larger such as black or king snakes add to the list toads, frogs, mice and birds. Though a final estimate cannot now be put on the value of all these snakes, it is clear that most of them do as much good as harm, to say the least, and many are extremely valuable friends of man. Lizards feed almost wholly upon insects, slugs, etc., and are decidedly helpful to man. Turtles, on the whole, probably do much more good than harm to man and deserve his protection.

The humble toad also renders considerable service to man. Kirkland summarizes his findings thus: "Against the toad must be reckoned the destruction of many beneficial ground beetles, a few spiders, an occasional carrion beetle, ladybird, ichneumon fly, forming as a whole 11 per cent of its food. To the credit of the toad we must place the destruction of a remarkably large number of particularly injurious insects. . . . The quantity of in-

jurious species destroyed forms 62 per cent of its total food." [25]

This great field of interrelations may be viewed from two standpoints: (1) that of the student who seeks to see and understand the series in a disinterested fashion; (2) that of the man seeking his own welfare indifferent to any scheme of nature save as it affects him. The student must not forget that his duty does not end with the accumulation of knowledge. The practical man must be willing to heed the advice of the student.

From the standpoint of the practical man it is not always easy to determine whether a given plant or animal is useful, neutral or injurious. Several facts must be kept in mind. A plant that hinders agriculture must be driven from that field at least. The animal that at times eats man's food supply may for the most part feed upon weeds or insects and thus save the farmer a far greater loss than it inflicts. The mere fact that it does damage is not sufficient to condemn it. Nor is the reverse true. An animal may do good and yet more than overbalance this by the damage it causes. In such cases the student must make the decision ultimately. The practical man must recognize that better care of his plants or animals may be by far a cheaper method of preventing loss than the destruction of the types doing some harm to his crops.

In these matters the average man is ignorant or indifferent, and this attitude is to be deplored. Other animals than man rarely kill except to get food for real necessities. The dog that gets the sheep-killing habit apparently shows the effect of his association with man. Here lies the great danger. The city-dwellers who seek the country

[25] KIRKLAND, A. H. Usefulness of the American Toad, p. 13.

and pick every flower in sight, frequently pulling up roots and all, are destroying some of our finest flowers. The pot hunter, the farmer who kills every time a cherry is taken, the woman who wears birds on her hats are not merely destroying the lower forms of life but are inflicting a terrific burden on the human race. The man who needlessly cripples the life of his descendants is as blameworthy as the one who wastes his own or commits suicide. In this same category comes the killing for food of varieties of infinitesimal value for that purpose.

The dangerous types of life today are not the biggest but the smallest. To fight these man needs the help of those for whom the dangerous types are the common supply of food. Big game is today making its last stand in the wilds of Asia, Africa and South America. Unless man stays his murderous hand, in a few years many forms of life which in ages to come may have the highest value will be gone forever.

It must be taken for granted that the settlement of any country like America will involve the disappearance of the big animals from the agricultural districts at least. When we read, however, that thousands of the bison were killed for hides or tongues alone, the carcasses being allowed to rot, we must ask as to the wisdom of the slaughter. Whether their disappearance from cultivated fields also justifies the extermination of large animals in the millions of acres of wild land is also open to question.

The influence of the incoming white man upon birds deserves attention. Until the nineteenth century man did not make any serious inroads, directly at least, on the number of birds. The bow and arrow, traps or birdlime were after all ineffective. Man had no motive for killing, nor could he afford the cost. Since that time, however,

by the development of the shotgun, the increasing destruction in the woods and copses, the cultivation of the fields and the development of the fashion of wearing birds on hats, immense havoc has been wrought.

There are about 1,100 species of birds in the United States. Of these some 900 are of little or no value as food, while about 200 may be considered as game birds. As a whole birds are much less common today than formerly and this is particularly true of the game birds and of those species of the first group which have been used in millinery or whose eggs have been made articles of commerce. Some common and valuable sorts have probably increased and these include robins, meadowlarks, kingbirds, sparrows, pewees and swallows.

In comparison with the other continents America was poorly stocked with the larger mammals, but it was very rich in bird life. Today in most of the land but a small fraction of that bird life survives. When we learn that in twelve months in 1909 and 1910, the official records show the killing of nearly 6,000,000 birds in Louisiana, the decrease is not hard to understand. How many others were actually killed no one knows. These birds were as follows:

| | |
|---|---|
| Wild ducks | 3,176,000 |
| Coots | 280,740 |
| Geese and brant | 202,210 |
| Snipe, sandpiper, plover | 606,635 |
| Bob-white | 1,140,750 |
| Mourning doves | 310,660 |
| Wild turkeys | 2,219 |
| | 5,719,214 [26] |

As a result of less than a century of carnage some species are entirely extinct. The passenger pigeon, once

[26] HORNADAY, W. T. o. c., p. 5.

present in such numbers that a single flight was estimated at 2,230,272,000 individuals, is extinct; the last known wild bird having been killed in Michigan in 1908. The last one in captivity died in the Cincinnati Zoölogical Garden, September 1, 1914. Yet this bird was shipped in 1869 from Hartford, Michigan, to the extent of three carloads a day for forty days, a total of 11,880,000 birds. The last living specimen of the great auk of the North Atlantic coast was seen in 1852. The Labrador duck was extinct by 1875, the Pallas cormorant about 1852. The Eskimo curlew has rarely been seen since 1900, the last specimens being taken in Nebraska in 1911. The Carolina parrakeet, formerly ranging over the entire central and southeastern states, now survives in captivity only.

At the very door of extinction, according to Hornaday, are the whooping crane, trumpeter swan, flamingo, spoonbill, scarlet ibis, American egret, snowy egret, wood duck, heath hen, pinnated grouse, prairie sharp-tailed grouse, sage grouse, golden plover, upland plover and a number of others. Some of these may be saved by prompt action — others are apparently doomed. Yet the wood duck is one of our most beautiful birds.

Probably the brutal side of man and woman has never been more clearly shown than in the killing of the egrets for the "aigrettes." This involves the killing in the breeding season of the adults, the young perishing in the nests. Millions of adult birds were killed, entire colonies being wiped out in a few days.

Now the larger game birds are gone, the hunter is turning his attention to those that remain. Ducks and geese exist in greatly diminished numbers. Quail are scarce. The prairie chicken is seldom seen east of the Mississippi and is far from common west of it. Robins, blackbirds,

meadow larks, bobolinks and doves are being shot as "game." Robins are "hunted" at their roosting places, and reports tell of the killing of 10,157 in two hours and ten minutes by seven men in Texas. A quarter of a million are killed in Louisiana for food yearly.

Sentimentalism aside, must we not ask ourselves what the results of this program will be? The answer is at hand. In 1913 the State Ornithologist of Massachusetts estimated the damage done to crops in the United States by the destruction of birds at $800,000,000 annually, which is equal to a tax of $1.67 per acre of improved land, a sum larger than the total tax collected on the same land for local or state purposes. Yet birds are an important factor in reducing insect pests, for, as some one has said, they "reduce to a lower level the great flood tide of insect life." The destruction of the insect-eating birds is, however, just beginning in the country at large. How large a bill will the American be willing to pay for the privilege of having other Americans — or immigrants — go a-hunting?

The bird lover may perhaps exaggerate the help given by birds in controlling insects. The entomologist is inclined to emphasize other factors. "It must be again emphasized that birds and other animals constitute only one of the checks to insect increase and, as against climate, disease, parasitic and predatory insects, a very minor and insignificant one. We must also remember again that for a naturally abundant species the abundance was fixed in spite of all the natural checks, including birds and animals. Now when such an abundant insect becomes destructive by reason of undue increase from any cause, the very last factor to become important in bringing it back to normal conditions is the vertebrate enemy list, in-

cluding birds, because their number and ability to consume remains practically a fixed quantity due to their slow rate of multiplication. It sounds large when we find 100 larvae of an elm-leaf beetle in a bird stomach and find 100 birds to an acre; but when we find 100 larvae on a dozen leaves and many thousands of leaves on a tree, the figures lose in impressiveness." Birds eat parasitized forms as well as healthy. The wood-leopard moth is injurious only in cities where the English sparrow keeps out other birds, though the writer thinks the sparrow did destroy the span-worm.[27]

No further argument would seem to be necessary to show that man must not carelessly upset this delicate balance of nature. This is not to be taken as an argument against such an upset for there can be no development without it. It merely means that man must count the cost.

Even where the change made is clearly for man's benefit, the results have always been uniformly satisfactory. In Montana I have seen acres of grain cut close to the ground by the prairie dogs, which were as fat as the ordinary pug dog. The new food supply had just met their taste and they reaped in advance of the farmer. The Department of Agriculture stated some years ago that the increase of these animals in parts of Kansas was an actual threat to the human population. In parts of California rabbits commit similar depredations, and great hunts are often organized to reduce their numbers.

Whenever man interferes in this great chain of interrelated forms of life, he runs great risk of producing the most unexpected results. Today in civilized lands few matters are more closely regulated than the importation

[27] Smith, J. B. o. c., p. 136 ff.

of strange forms of life, and the bringing in of those likely in any way to cause trouble is strictly prohibited. This is the result of experience. To be sure all our domestic animals have been brought here. Unfortunately all our importations have not been so happy.

Go where you will in the East today and the old, neglected apple orchards are full of dead limbs. Examine the twigs and if not too long dead they will look as if there had been some eruption on the bark. In orchards properly cared for once or twice a year the trees are all sprayed with some oil or salt and sulphur solution. Years ago there came in on fruit stock from Asia what we now call the San José scale. It is a minute shield protecting a tiny body fastened to the bark as by a pin. Yet this insignificant scale increases so rapidly and is spread so fast by birds that in a generation the country is practically covered. It was spread in a measure also by the nurseries which scattered infected stock ere its significance was known. Attacking a large share of our prized fruit trees it imposes a burden of care and expense that is enormous, or else destroys our fruit. We are encouraged by the fact that the scale has been attacked by a parasite which has destroyed it in some districts.

In 1868 or 1869 a French entomologist near Boston was experimenting with gypsy moths hoping to find a cocoon of commercial value. A storm set some of the moths free. The anxiety of the student to recover the specimens was ridiculed. Down to 1912 the government and the New England States had spent some $7,680,000 in the effort to get rid of them and no New Englander treats the subject as a joke, though I am told that the canny inspectors are careful to miss enough nests to make sure of their jobs the next season. About the first of August the

wingless female gypsy moth crawls to some sheltered spot on a tree and lays masses of perhaps 250 eggs each. These hatch out the next May and the young begin to eat the leaves. As if this were not enough the brown-tailed moth has appeared. These may often be seen in great pasty white masses covering electric poles, wires and globes in the evenings. In July the female lays her eggs on some leaf. These hatch in a few days and feeding begins. Then a winter nest is made of leaves which remain decorating the tips of the branches till spring. From scattered spots on the Maine coast down to Fall River and west to the Berkshires these enemies of foliage have spread. If the shade trees are to be saved a constant warfare must be waged.

The European house sparrow known to us as the English sparrow was introduced by would-be public benefactors. As Hornaday says, "It is a national sorrow almost too great to be endured." [28] So far as we can see it is a quarrelsome, noisy, dirty bird which has driven out of the towns many desirable native species. It prefers grain to weeds and its board bill is large. On one occasion I saw it eating brown-tailed moths and I hope against hope that this may become a habit. The bird was introduced into America in 1850 by the directors of the Brooklyn Institute. In the next decade it appeared in a number of places in the country, having been brought over apparently by Europeans who missed it. It was likewise taken to Australia and has given the same trouble there. The European starling, another bird of doubtful virtue first liberated in Central Park, New York City, in 1890, has now spread from Massachusetts to Virginia and may

[28] HORNADAY, W. T. o. c., p. 334.

become a serious menace to the fruit industry as it has in Australia.

The English introduced the rabbit into Australia about 1860. The results were astounding; grass, bark of trees, fruit and vegetables were consumed. "In order to protect such portions of the country as are still free from rabbits, fences of wire netting have been erected; one of these fences erected by the government of Victoria extending for a distance of upwards of one hundred and fifty geographical miles. In New Zealand, where the rabbit has been introduced little more than twenty years, its increase has been so enormous, and the destruction it inflicts so great, that in some districts it has actually been a question whether colonists should not vacate the country rather than attempt to fight against the plague. The average number of rabbit skins exported annually from New Zealand is now twelve millions." [29]

In 1872 the mongoose, which in its Indian home feeds on rats and snakes, was introduced into Barbados and Jamaica to get rid of the rats which were injuring the cane fields. The attempt was only too successful. The rats gone, birds and chickens were attacked; even the cane has been attacked, and everywhere the mongoose is a scourge. Now we are told that owing to the absence of the birds Jamaica is having trouble with ticks introduced from Mexico. The mongoose has reached many other islands of the Caribbean and Hawaii. "The progress of the pest is everywhere the same,— sweeping destruction of rats, snakes, wild birds, small mammals and finally poultry and vegetables." [30] If it ever gets loose in this

[29] Hornaday, W. T. o. c., p. 331.
[30] Ibid., p. 333.

country it will be a serious matter. It is claimed that Florida is having increased difficulty from moccasins and muskrats because of the killing of the alligators. In like unconscious fashion the insect phylloxera, was introduced from America into France and nearly destroyed the vine culture. The American grape vines when attacked threw out new root shoots but the European vines did not, hence were killed. The Colorado beetle has made its way across the continent in three years, and even to Ireland. The Hessian fly, the Argentine ant, the horn fly, the wood leopard moth and the elm-leaf beetle are other undesirable immigrants. In a word, some of our greatest burdens have been brought upon us by our ignorant or careless upset of nature's balance.

In earlier times man did relatively little harm to those forms of life on which he most directly depended. This was due in part to a lack of death-dealing weapons; in part to the absence of the philosophy expressed in what has been considered a characteristic English fashion: "It's a fine day — let's go and kill something." The ruthless slaughter of the last three centuries has worked irreparable damage in many ways. There are many signs that man is coming to realize that he is not free to lord it over nature and wantonly destroy her lowlier forms unless he wishes at the same time to make his own life more difficult, perhaps impossible. The recognition that he is a part of nature is bound to change his attitude. Instead of trying to catalogue plants and animals either as friends or enemies he begins to see that each plays some part in the whole cycle. Some he must destroy lest they destroy him. Many more he must protect even though they do him some small harm because of the infinite services they

render. Many he must leave where they are lest under new surroundings they change their habits.

The stronger winged grasshoppers were able to fly "hundreds of miles from the Rocky Mountains to the Mississippi Valley, alighting first where cultivated lands begin. Thus Kansas, Nebraska and the Dakotas were preëminently sufferers from grasshopper invasions, and not infrequently conditions were sufficiently good there to permit the insects to lay their eggs, providing for a brood which the year following destroyed the vegetation while still unfledged, and then migrated yet further east to do destructive work as adults and to perish gradually, in the egg stage, in the moist unsuitable soil. . . . No one who has not seen grasshoppers in this Western country can form any real idea of their actual abundance, and their destructiveness has been the theme of many a writer. . . . Conditions now are much better than they were and can never again be quite as bad. A large area of what was at one time ideal breeding ground, is now irrigated and under cultivation, and the enormous belt of alfalfa and other crops now basing the foothills, checks and takes up the migrating hordes that occasionally start from the uncultivated areas. The march of advancing civilization spells the doom of some of these grasshopper species, as it has that of many another animal." [31]

The Department of Agriculture has recently published a bulletin based on the reports of some two hundred observers in the district east of Kansas and north of North Carolina. There were found for each 100 robins about 83 English sparrows, 49 catbirds, 37 brown-thrashers, 28 house-wrens, 27 kingbirds, and 26 bluebirds.

[31] SMITH, J. B. o. c., p. 56.

"The census covered 58 of the 108 acres of the average farm of the Northeastern States and revealed on this area a bird population of 69 nesting pairs, and on the remaining 50 acres it is estimated that there would be about one pair to the acre; in all, 114 nesting pairs to the 108 acres of farmed land. On the 46 acres of wild land existing for each 108 acres of farmed land it is safe to assume that there would be fewer birds than on the census covered area." Heavy forests contain relatively few birds. The only large census returned showed in an Idaho forest 254 pairs of breeding birds on 768 acres.

The densest bird population was in the town of Chevy Chase, Maryland, in which the houses are surrounded by large yards containing many trees. Thirty-four different species were found nesting on the twenty-three acres examined, with a total of 148 pairs of native birds and thirteen pairs of English sparrows.

"An approximate average of one pair of birds to each acre of farm land was found, but individual censuses show that it is possible, under strictly farm conditions, very largely to increase this number. Near Wellington, Va., a tract of 49 acres of a dairy farm, of rather less than the average of plowed land, supported a bird population of 137 pairs, or 3 pairs to the acre. . . . Near Albany, Mo., 80 acres was divided into 14 acres of plowed land, 27 acres of hayfields, a brushy pasture, with a little heavy timber along the banks of a small stream, and the customary farmyard, orchard, garden, etc. The conditions for bird life were probably more favorable than the average, but not sufficiently different to account for the 298 pairs of birds nesting on the tract."

"On a 50 acre tract at Viresca, Va., where the birds have been strictly protected during the last seven years,

exact censuses show a 50 per cent increase in the birds during the last four years." [32]

After twenty-five years of agitation the government of the United States began in 1913 the control of all migratory birds, its law supplanting all state laws, determining the conditions under which they may be killed and sold. The importation of egret plumes, etc., has been prohibited. Mrs. Sage has given Marsh Island in the Gulf of Mexico to the government as a bird refuge. The success here has stimulated similar movements in Europe. Game preserves are being established by both state and national governments as well as by private citizens. It is not too much to hope that we are entering a new era in our relations to nature. The control to be discussed in the next chapter is the direction of nature's forces to produce the maximum of good to ourselves not the reckless and short-sighted display of mere brute force and the destruction of the very basis of our life.

## SUGGESTIONS FOR READING

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## CHAPTER III

### THE CONTROL OF NATURE

Man's earliest arms were fingers, teeth, and nails,
And stones and fragments from the branching woods;
Then copper next: and last, as latest traced,
The tyrant, iron. — LUCRETIUS.

Man's belief that he is to dominate this earth has never been better expressed than by the poet who first wrote the words: "And God said unto them, Be fruitful and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth." When His Highness, the Elephant, walks down the street of some Indian village, no person challenges his right of way. With one accord he is given a clear road. Yet on his back is a man, diminutive by comparison, to whose orders the giant is obedient. In this simple incident we have an epitome of history. Man is by no means one of the largest and strongest animals of earth. Yet today he is the master. Existence depends upon the use of the facilities offered by nature. Civilization depends upon the direction or control of these facilities for man's benefit. We must be on guard lest we overemphasize the degree of our mastery. By control we really mean the use of the materials of nature to accomplish our ends. We cannot change the law of gravity but we can utilize it to make the weight run the clock or the balloon to rise. We

cannot cause the wind to blow nor prevent it but we can make it run the windmill and grind the corn or drive the sail boat. Our control over large animals is based on our intellectual superiority, for if the elephant bolts or the horse runs we are physically almost helpless.

It is hard for us to realize that for long ages this dominance did not exist. We must picture primitive man as living in groups, feeding on fruits, nuts, insects, shellfish or other easily obtained foods. Once in a while a whale might be cast on the shore or an elephant killed by accident and thus man be given an unexpected feast. As a rule when the wild beasts appeared man sought safety in flight, not infrequently in vain. If food was abundant he grew fat, if scanty he starved. For him, as for us today, the first steps in any direction must have been the most difficult. The discovery of the possibilities of the stone or club marked a great epoch. Crude as these weapons are, they mark the beginnings of the control over nature on which civilization depends. It shows how far we have lost sight of fundamentals in that we no longer honor him who first made fire by rubbing two sticks together, and made possible the torch to show the path, the heat for house and body, the change from raw to cooked food.

After man invented the drill and bow drill for making fire, long ages passed ere he secured easier methods. Until the nineteenth century flint and steel were commonly used. The word match was originally used to indicate the hemp or other fiber which carried the flame to the oil or powder.

In 1680 Haukwitz and Boyle used phosphorus ignited by friction to light splints of wood dipped in sulphur. This was rather dangerous. In 1805 Chancel, at Paris, devised the scheme of keeping asbestos soaked in sulphuric

acid in a bottle into which a sulphur-coated stick tipped with chlorate of potash and sugar was dipped, the fire resulting from chemical action. In 1827 Walker, of England, invented a friction match and in 1833 the common phosphorous friction match appeared in several places, notably Vienna. The first safety matches were made in 1852 in Sweden.

"The physical forces and mechanical powers were at first unknown and entirely useless to both man and woman. Only gradually were they brought within the area of intelligence and control. Savages know an inclined plane, the wedge, lever, a lubricant, a roller, the pulley, in the crude form, but not the wheel in any of its combinations. . . . Chief of all should we keep in mind the fly-wheel on the spindle, the first device ever made by human beings for converting rectilinear into circular motion." [1] Gladstone called the wheel the most wonderful of man's inventions, for there was nothing in nature to suggest it. The bow and arrow must be regarded as one of the greatest inventions of all ages. We shall never know to what race, era, or continent these early inventors belonged; nor whether the devices were worked out in one place and then copied all over earth, or rediscovered in various places by many persons. Nevertheless, we owe endless gratitude to those unknown inventors in the dim, gray dawn of history who made possible the first upward steps.

Many of man's early discoveries, like many of the later, were quite accidental; others were suggested to him by animals. Long before he thought of doing things himself, he had found the honeycombs of the bees, had seen hawks catching fish, had marveled at the delicacy of the spider's web and understood its purpose and had investigated the

[1] Mason, O. T. Woman's Share in Primitive Culture, p. 279.

paper nest of the hornet and been received with unexpected warmth. He had robbed the squirrels of their nuts, had dug open the ants' nests and had seen the ponds constructed by beavers. All of these animals had modified their world to some extent to meet their own needs. Many had dug holes in earth or trees. The stickleback and other fish had made nests. Birds, like the cowbird and European cuckoo, deposited their eggs in bird orphan asylums, unwittingly conducted by other species, and left the labor of hatching and rearing to the foster parents. Some, like the turtle dove and American cuckoo, were satisfied to make a loose flimsy framework of sticks as apologies for nests; while others, like the Baltimore oriole, were expert weavers. From these and the endless other examples before him, man must have gotten invaluable hints and suggestions. We must realize that each step led not merely to better methods of living, but also created a keener intellectual appreciation of the possibilities of the situation and thus stimulated discovery.

Why all groups of men have not equally profited from these lessons must be elsewhere considered. As we glance over the peoples on earth today we find that they may be roughly classified in accordance with their dominant pursuits as hunters or fishers, herdsmen, farmers and manufacturers. That none of them quite correspond to primitive man is shown by the fact that they all have tools and weapons and understand the art of fire making. It was formerly supposed that the entire human race had passed through these stages in the order named. Now that we realize that man has been on earth much longer than was formerly supposed and knows more about the various peoples, it seems likely that his forward march has been guided by his physical opportunities in large

measure. The Japanese became agriculturists (as did the Hopi Indians) without domestic animals, and now are becoming in a few years skilled manufacturers because of contact with Western peoples. The Navajos were agriculturists and hunters; after the Spanish introduced the sheep, they became herdsmen.

Whenever man made a new invention, or discovered some method of bettering himself, he did one of two things: either he provided some sort of insurance against a time of need (as by storing food) or else he extended his own powers in time and space. He could kill a rabbit with a club or even run down a deer, perchance, but the bow and arrow brought great saving of effort and made his strength effective for one or two hundred yards, thus radically changing the nature of his contest with other animals. Every such saving of time and effort increased his productive ability, enabled him to have leisure for other activities and made possible the production of surplus wealth. Sad experience taught him that the arrow shot from the bow could not always be found or used again. In some such way he discovered the great truth that wealth is made to be used and so is soon destroyed and must be replaced. Even his most permanent and substantial buildings seldom last a century, and then only with constant repair. When the development had gone far enough, he gradually changed from casual to regular labor; but long ere this day dawned, his standards were relatively high. Thus he finds that wealth is the material basis for civilization and a work ideal replaces one of pleasure.

Whenever man has gone to any region of earth in which it was possible for man to exist, he has found other men already on the ground. This wide distribution, greater than that of any other of the higher animals has been

possible because of man's ingenuity in using the materials offered in the various localities, his habit of taking tools, plants and animals with him and in later periods the maintenance of commerce with the old home. The daily life of these different groups shows wide differences, and yet underlying all are certain fundamentals which may be indicated. If man is to exist — particularly if he is to acquire any degree of culture — he must secure a permanent food supply, get adequate clothing and find or construct caves, houses or shelters of some sort. In the higher stages some control of light, heat and power is also essential. In addition protection against enemies, whatever these may be, is, to say the least, desirable. The obviously dangerous enemies of primitive man were the large animals, while civilized man must defend himself against the minute forms of life which we may group under the term contagious diseases. Inasmuch as a mere list of man's achievements would fill volumes, we can give here only a few illustrations of the various ways in which man exercises his control. Furthermore, we must limit ourselves to the bases of our own civilization.

Perhaps the most striking evidence of man's control is the decrease in the amount of land required as civilization develops.

"Hunter tribes on the outskirts of the habitable area, as in Arctic America and Siberia, require from 70 to 200 square miles per capita; in arid lands, like the Kalahari Desert and Patagonia, 40 to 200 square miles per capita; in choice districts and combining with the chase some primitive agriculture, as did the Cherokee, Shawnee and Iroquois Indians, the Dyaks of Borneo and the Papuans of New Guinea, 1.2 to 2 square miles per capita.

"Pastoral nomads show a density of from 2 to 5 to the

square mile; practicing some agriculture, as in Kordofan and Sennar districts of eastern Sudan, 10 to 15 to the square mile. Agriculture, undeveloped but combined with some trade and industry as in equatorial Africa, Borneo and most of the Central American States, supports 5 to 15 to the square mile; practiced with European methods in young or colonial lands, as in Arkansas, Texas, Minnesota, Hawaii, Canada and Argentine, or in European lands with unfavorable climate, up to 25 to the square mile.

"Pure agricultural lands of Central Europe support 100 to the square mile, and those of southern Europe 200; when combining some industry, from 250 to 300. But these figures rise to 500 or more in lowland India and China. Industrial districts of modern Europe, such as England, Belgium, Saxony, Departments Nord and Rhone in France, show a density of 500 to 800 to the square mile." [2]

A great change from extensive to intensive agriculture is now taking place in this country. In the Middle West two men will do all the work save at special rush times on a farm of two hundred acres, while in highly developed market gardening in the East about one man per acre is required. Less land is required, but at a steadily diminishing return per man.

In order to carry on his activities man had to be able to use his eyes, that is to see. In the early ages then he had to depend on the light furnished by the sun, moon and stars. Later the glare of the bonfire or the flickering pine knot helped him find his way in the dark. In time the knot yielded place to the torch or lamp with a wick of some vegetable fiber and supplied with animal or vegetable

[2] SEMPLE, E. T. o. c., p. 65.

oil. Candles of wax or beef-tallow were made by the Romans and there were guilds of candle-makers in north Europe in the thirteenth century. Sperm candles appear about 1750 and become the standard of light. Even today by the term candle-power we mean a sperm candle $\frac{1}{6}$ of a pound in weight burning 120 grains per hour. A private house was illuminated by coal-gas in 1792 in England; its use in London began in 1807; but it was not common until 1819; while the use of kerosene was not general even in America until after 1859. Electric light was still a curiosity at the Centennial Exposition in 1876, while the regular use of acetylene is still later.

Man's advance in any one art is always conditioned upon the development of other arts whose products must be used in the first. For instance, modern surgery turns upon the use of mirrors, artificial lights, antiseptic dressings and sharp cutting instruments, as well as on a greater knowledge of anatomy. So primitive man learned to construct rude shelters of leaves, branches or tree trunks felled by fire; but, practically speaking, he could neither make nor use lumber until he had possessed himself of metal tools. He came therefore to depend on bricks, sun-dried at first, or on stones for his better structures. When once he had discovered the principle of the arch he could erect massive and enduring monuments. Yet until he had domesticated animals the human cost of a large building must have been enormous. Unless the ancient Egyptians possessed machinery of which all record has been lost, what human energy must have been required in the construction of the pyramids!

We have already seen how important the hydrocarbons are to all organisms. They have been equally valuable to man in his arts. Long ages ago in the Carboniferous

era vast forests grew and died; and by a series of changes, chemical as well as mechanical, were turned into coal in its various forms. We may classify these in accordance with their carbon content, remembering that the series really begins with living wood containing about 50 per cent carbon and ends with the diamond which is practically pure carbon: Lignite, 67 per cent; cannel, 64 per cent; bituminous, 88 per cent, and anthracite, 93 per cent; to which we should add graphite, 95 per cent. That these have different properties and are valuable for various purposes is well known.

Coal was more or less known to the Romans and was slightly used by them as well as by the Chinese. It was mined in small quantities in England before the coming of the Saxons. Little attention was paid to it until the gradual decrease in the forested area by the ninth century. There is an English charter permitting the freemen of Newcastle to mine coal dating from 1239. Thereafter it came gradually into use but at the end of the sixteenth century two ships were able to keep the London market supplied. There was much opposition to its use on the ground of the smoke and dirt and at times it was prohibited particularly during the session of Parliament. In America bituminous coal was mined in Virginia about 1750 and at Pittsburgh in the following decade. Anthracite was discovered at Wilkesbarre in 1762 but was little used, as the people did not know how to burn it. It was used at Carlisle during the Revolution for the manufacture of firearms but as late as 1820 the Philadelphia market was satisfied with 365 tons from Lehigh.

The first coal product to be commercially used was illuminating gas which dates, as above indicated, from the end of the eighteenth century. In the process of manu-

facture many other substances are given off which were wasted at first but which have now become very valuable. The first of these is crude tar; then by further distillation, naphtha, ammonia, benzene, vaseline, the heavy lubricating oils, paraffin, aniline and others. By different processes we get coke, soot and lampblack.

Natural petroleum was known at least five centuries before Christ and was used, it is believed, in keeping alight the sacred fires in the Persian temples. Marco Polo writing about A.D. 1260 mentions its use. Until the discovery of the oil wells of Pennsylvania it had little importance. So too asphalt seems to have been known and used in Egypt and Babylon but only recently, through the discoveries of the lakes in Trinidad and elsewhere, has it come into general use.

Now either directly from coal or from related substances come a considerable percentage of some of our most highly valued commodities. Aniline dyes which have made possible the colors of our clothing materials were developed after 1836 and became important by the middle of the century. Another product is carbolic acid.

Meantime coal, kerosene and gasolene furnish us with light for our houses and streets, with fuel for our engines and motors, with heat for our buildings; and have made possible a wonderful change in our daily life and industrial processes. Through their use we are able to make iron the basic material of our economic life.

The use of the sharp edge of shells or slices of stone as scrapers or knives marked a great advance. A new era dawned when man first discovered the softer metals, copper, lead and tin. The next stage is marked by the making of the alloys — brass and bronze. Relatively late, man began to forge tools of iron and really entered upon the

metal stage. We should not forget that until the nineteenth century man depended upon the scanty supply of pure metal he could find. The ores which today form the basis of the iron industry were as meaningless to him as was the bog iron, so prized by the first whites in America, to the Indians. It is not an exaggeration today to say that our industry rests on iron foundations. But pure iron is rather soft and rusts badly, hence it is hard to preserve tools or keep sharp cutting edges. The next great step was the discovery of the art of making steel by mixing carbon with the iron. Even this could not be used in large quantities, because of its cost, until Bessemer invented his process in 1864. The cost of steel rails for the railways soon fell from $175 per ton to the neighborhood of $30. Today America produces 40 per cent of the steel of the world. But carbon steel has certain defects. It shows a crystalline structure and cracks rather easily. Now nickel steels are used for many purposes as they are harder and stronger and do not rust. Combined with chromium and molybdenum, steels are now made which resist such strong acids as hydrochloric or nitric, in some cases even *aqua regia.* Steels which remain hard at high temperatures are produced by alloys with chromium, tungsten and vanadium. Immense improvement in cutting tools has come through these new alloys. Safes are now made of these alloys which have not yielded to one and one-half hours' exposure to the intense heat of oxyhydrogen and oxyacetylene flames. These discoveries conditioned as they are upon the newer chemistry indicate that the possibilities of metallurgy are far from exhausted. It is a long journey from the fire-hardened stick, which was plow and hoe to the primitive agriculturist, to the iron plows, mowers and binders of today; but farming

tools changed less from the time of Herodotus to 1850 than they have since, so recent is this control. By 1868 iron bridges began to replace wooden. Now all structural iron work is made according to plans so that it can be rapidly placed and fastened.

It is hard for those of us who live in coal-burning regions to realize that the mass of humanity does not depend on it for heat. It is even harder to realize that chimneys were unknown before the twelfth century and that fireplaces when first used had very short flues, the smoke making its way to the outer air through openings in the wall just above the fire-place. Even today the brazier of coal or charcoal is characteristic of southern Europe. In 1744 Benjamin Franklin devised the cast-iron open heater still known by his name, while cast-iron box stoves appear by 1752 and the base-burner not until 1830. Like all other really great machines, the steam-engine is a product of many ages and many inventions. One hundred and thirty years before Christ, Hero described a simple engine of no practical use and there was no advance upon his knowledge until the seventeenth century. In 1663 Edward Somerset used an engine for the purpose of raising water and the first engine of real commercial value was made in 1698 by Thomas Savery. The discoveries of Denis Papin (1690), of Thomas Newcomer (1705) and others culminated in the work of James Watt (1763). By 1802 William Symington had constructed a tug operated by an engine and in 1807 Robert Fulton made his world famed trips. In 1829 George Stephenson built the first locomotive "The Rocket" and began the operation of the first railroad, built, appropriately enough, for the hauling of coal. The turbine engines date from about 1884; the Diesel engines from 1897.

Inasmuch as the coal supply of the world is limited it becomes a matter of importance to know that it is not wasted. When we realize that some 90 per cent of the heat goes up the chimney rather than warms the house it is clear that there is great loss. The ordinary reciprocating engine utilizes only 9 per cent of the energy of the fuel, the turbine some 12 per cent, while the new Diesel engines are claimed to get 36 per cent. Many problems must be solved ere the last mentioned engines are generally available, not to speak of the problem of reducing the waste still further.

Until the development of the coal and iron industry, there had been little improvements upon the methods of control of the Romans. With the invention of power machinery comes a great series of parallel developments of which electricity is an excellent illustration.

Through all time the lightning had terrified men and stirred their imagination. Some of the simpler phenomena of electricity and magnetism were known. Franklin, in 1752, proved the identity of lightning and electric sparks. Then began one of the most wonderful series of discoveries and inventions the world has seen. To this series contributions were made by men of all the civilized races and lands. It is impossible even to list these men and their discoveries. We need only recall the electric light, telephone, telegraph, ocean cable, phonograph, kinetoscope and other machines which have almost revolutionized conditions of life.

Great electric power plants appeared after 1890 and a new group of industries developed. Aluminum, which cost before $25 a pound to produce, is now secured for a few cents. Calcium carbide from which acetylene light is made now retails at less than four cents a pound. There

has come also the present possibility of transporting power over long distances by using the electric current. Thus we may utilize water power miles from its source or burn coal, oftentimes of too low grade to justify shipment, at the mine or central plant and thus save the cost of hauling. In spite of these wonderful achievements we are in reality just starting our use of electricity.

Accompanying the development of power machinery and electricity, and to a considerable degree made possible by them, has come a wonderful advance in chemistry. This does not merely increase our power of analysis resulting in greater knowledge, but enables us to produce new things. It is synthetic.

By electrolysis an iron is now produced not much harder than aluminum which can be magnetized much more quickly than ordinary iron, and which loses its magnetism more readily, thus greatly increasing the efficiency of electromotors. Electrolytic processes are largely employed in producing nitrogen from the air, in the making of chlorates and in the recovery of the tin from old cans. Electro-chemical works are now producing rubies and sapphires identical with natural stones, save in their source. The aniline dyes obtained from the hydrocarbons contained in coal tar are so varied that the chemist claims that he can produce almost any shade of color in wool, cotton, silk or paper. Even the purple of the ancients can now be manufactured. Medicinal drugs artificially created, such as phenacetin, sulphonal, adrenalin, caffein, theobromin, tannin, camphor and atropin are on the market. The odor of the rose, violet and lily-of-the-valley can be duplicated in the laboratory. Artificial silk may yet rival the genuine. A non-inflammable celluloid (cellon) has been devised. In 1894 the fact that rubber could

be synthetically produced was discovered by Tilden but the process was not invented till 1909 by Fritz Hofman, and is still too expensive for commercial use. Indeed, one might say that life itself is the only thing the chemist cannot produce. Some of his compounds come so close to the line that there is growing belief amongst scientists that some day some one will hit upon the secret.

This crude sketch of the physical factors must suffice. We must now consider the control of the organic world, and that largely from the standpoint of food. In the lower stages, man uses a wide variety of both plants and animals; but as the higher levels are reached, he comes to depend on the relatively few that have proven most satisfactory and reliable, either in reality or in fancy. Thus on earth today not more than 300 species of plants are widely used out of the 150,000 man has listed in his catalogues; not more than 200 animals are of importance out of the vast hordes (millions, perhaps) that exist.

When the mists begin to clear at the dawn of history, we find the peoples of Egypt and southwestern Asia in possession of a number of the most important plants known. When America was discovered, the Indians in America were cultivating about all the important native plants known to us. So ancient is agriculture that De Candolle says: "Men have not discovered and cultivated within the last two thousand years a single species which can rival maize, rice, the sweet potato, the potato, the bread fruit, the date, cereals, millets, sorghum, the banana and soy. These date from three, four or five thousand years, perhaps even in some cases six thousand years." [3] This statement applies primarily to food plants.

At least two plants of very great importance have been

[3] DE CANDOLLE, A. Origin of Cultivated Plants, p. 451.

brought under cultivation recently and both come from South America. The highly esteemed medicine quinine comes from the cinchona tree. There are ten or twelve important varieties of the cinchona, all native of the mountainous western coast, from which quinine is derived. These were transplanted to India in 1861 and have succeeded under cultivation. It is stated that the rubber goods now manufactured each year on earth are worth $750,000,000, the raw material being valued at $250,000,000. Brazil exported 2,671 tons in 1860, 15,354 in 1890, and 38,200 in 1910. Up to 1900 the wild plants were the source of supply. Of these there are many varieties, but the chief dependence is upon the Para rubber tree. Since 1900 this plant has been set out in great plantations, one of 20,000 acres is reported in Sumatra. By 1913 there were 250,000 acres planted in Ceylon; 420,000 in the Malay States; 40,000 in South India; 45,000 in the German colonies and 100,000 more in Mexico, Brazil, West Indies and South Africa. In spite of this and the fact that since 1880 the United States has used two pounds of reclaimed rubber to one of new, the price has increased, owing to the tremendous demand for insulating material for electric purposes and more particularly to the world-wide increase in automobiles.

It is interesting to note the origin of the plants that have been of the largest value to the race as a whole, omitting for the sake of brevity plants used chiefly for lumber, medicine or mechanical purposes. From southern and eastern Asia came the orange, lemon, rice, sugar cane, banana, apricot, peach, tea and cotton; from the East Indies the cocoanut. From southwestern Asia and northeastern Africa flax and barley (two of the oldest cultivated plants), wheat (also very old and grown in China 2700

B.C.); olive, grape, sour cherry, plum, almond, quince, fig, date palm, onion, cabbage, radish, turnip, lettuce, spinach, lentils, numerous gourds and melons, garden peas and coffee (Abyssinia). Europe contributed the apple, pear, gooseberry, currant, oats; while rye is a late comer from the distant north of the Caspian. Central and South America have furnished potato, sweet potato, maize, manioc, pineapple, tomato, cacao, tobacco and perhaps Sea Island cotton. The entire balance of North America has made almost no contribution. To quote De Candolle again: "A noteworthy fact is the absence in some countries of indigenous cultivated plants. For instance, we have none from the Arctic or Antarctic regions, where, it is true, the flowers consist of but few species. The United States, in spite of their vast territory, which will soon support hundreds of millions of inhabitants, only yields as nutritious plants worth cultivating the Jerusalem artichoke and the gourds (pumpkin and squash). *Zizania aquatica* (wild rice) which the natives gathered is a grass too inferior to rice to make it worth planting it. They had a few bulbs and edible berries, but they have not tried to cultivate them, having early received the maize which was worth far more."[4] Our vast hay crop is largely based on the clovers and timothy of Europe or the alfalfa of Asia. In our orchard fruit trees traveling both east and west from Asia again interlock branches, or blend as in the Santa Clara Valley in spring in one great orgy of color. Today agents are searching the earth to find plant types adapted to certain conditions and the last decade has witnessed the introduction of many new forms that promise much for the future. Throughout all historic time this exchange of plants has gone on — sometimes with wonderful rapid-

[4] DE CANDOLLE, A. o. c., p. 448.

ity. One needs but recall the rapid spread of manioc in Africa, the potato in Ireland or the world-wide extension of the use of tobacco.

Man has not merely taken advantage of the new types that have appeared but by deliberate crossing he has eliminated weaknesses or combined good traits. He has thus developed the old "love apple," which was little more than a seedy core with an attractive skin, into the luscious tomato, now one of the most important and valuable vegetables of the garden. He has produced types yielding larger crops of seed or stalk. He has combined sturdy, disease-resisting stocks with those producing superior fruit. He has discovered the secrets of grafting and budding and has obtained thus better plants and rapidly spread new varieties. The production by Burbank of a spineless cactus of value as forage may make possible the use of great areas of semi-arid land.

Just when man began to notice that some plants or seeds were larger or better than others, we shall never learn. All that we know is that he did and thus began a process of selection which has given us varieties superior from our standpoint to the originals. That this selection did not begin early may be inferred from the fact that our own farmers paid little attention to seed corn or cotton until the last two decades. The very success of this process has led to the failure to use many species which might perchance have become quite as valuable as the others. Thus it is easier to borrow plants from other people than to begin the long process of developing a new variety. It is this fact quite as much as mere paucity of possible varieties which has made the contributions of the newer continents seem so insignificant.

The absence of nuts from this list will be noted. These

were much used in early days both for man and beast — the oak groves, for instance, being highly esteemed because of the acorns for the swine. They are not, however, easily cultivated. Primitive man uses annuals or biennials in preference even to perennials. His habitation must be very permanent ere he turns his attention to trees. Slowly man has come to recognize the value of nuts and fruit and some day ere long he will devote much more attention to the crops that do not need replanting more than once or twice a century. In the United States millions of peach, apple and other fruit trees are planted yearly — most of those perhaps die through neglect, but the increase is marked. We are coming to see that many steep hillsides would be far more valuable if planted with trees than they are for tillage, and the belief in reforestation is growing.

Wherever man goes on earth he takes his favorite plants and grows them if possible. One needs but look at the United States to see this. With the exception of the potato and corn our cultivated food and fodder plants have been introduced. In one century we have raised cotton from an insignificant position to the rank of the most important supply of clothing in the world, and incidentally give the world a better supply of clothing than it has ever had. Our cotton crop is now some 13,000,000 bales, or about two-thirds of the world's supply. But cotton came from India and was largely an ornamental until the cotton gin was invented. Our potatoes came from South America and were not known here till after the coming of the Europeans.

The cultivation of one type of plants may make possible the increased use of other kinds. The vast increase in the use of sugar made from cane or beets makes palatable

many of the cereals and sourer fruits, and thus stimulates their cultivation as well as enriches our diet.

Today, thanks to man's inventions, we are no longer limited in diet to the plants of our own locality. Commerce places at our doors the products of a large part of the earth. The Boston family drinks coffee labeled "Mocha" which grew in Brazil; or tea, from China. The spices come from the Orient, the potatoes from Maine, the fruit from California or the West Indies and the beef from Montana or Argentina. This result is secured not merely by speed of transport but by ability to control temperature. Thus have arisen two apparently opposite processes: cold storage and hothouse production.

Cold storage is frequently decried by thoughtless people as if it were a scheme to put decayed foodstuffs on the market. This practice is just as common in communities where there are no opportunities for cold storage, and therefore is quite incidental. The real virtue of the system (aside from facilitating transportation in warm weather) lies in the fact that some commodity such as eggs may be stored when they are very abundant, as in spring and early summer, and marketed when they are very scarce, as in December. Were it not for this the price of eggs would be prohibitive to all but the rich during the winter, and there would not be enough eggs to go around at any price. Cold storage thus tends to equalize both price and supply.

Hothouses enable us to grow plants at otherwise impossible seasons. The development of this industry has been enormous and it is hard to realize the amount of fruit, green vegetables, mushrooms, flowers, etc., now supplied to our city markets thereby. Even in our North-

ern cities it is possible to get such articles practically throughout the year.

So far we have considered man's control of the plant world almost solely from the standpoint of food supply; but there are other very important aspects to be mentioned. Up to the present time most of these other uses have illustrated man's dependence upon nature rather than his control. A large part of the human race depends directly upon wood for its supply of fuel. Trees have also furnished the bulk of man's building materials. These two combined have resulted in the destruction of the forests over large areas. The growing scarcity has forced man to try to find substitutes for wood and also has led to the planting of forests. Our great railroad corporations are planting extensive tracts to provide ties, etc., for the future. In such countries as Germany, forestry has become a profession and strict public control is exercised over the timber resources. In large part also man's supply of medicine is still gotten from wild plants, though this is decreasingly true.

That a "man shall not live by bread alone" was recognized long ago. One of the most important uses of plants is as "ornamentals." The beauty of leaf and flower, the pleasing perfume early caught man's attention. Gradually he began to cultivate flowers. Western Europe thinks of the Turk as the embodiment of cruelty, forgetting among other things that to the Turk's love of flowers it is indebted for the tulips, lilacs, hyacinths, fritillaria, impatiens, buttercup, mimosa, hibiscus and horsechestnut. The devotion of various peoples to certain plants is well known, for instance: the Egyptians to the lotus and the Japanese to cherry blossoms or iris. Man has taken his

flowers whenever possible on his migrations. Indeed, some of our weed pests were carried because of their flowers. From Europe came with early settlers crown imperials, bleeding hearts, peonies, and many others to fill "the old-fashioned hardy garden." In truly human-like fashion, our forefathers ignored in large measure the native plants, but returning ships took back many of the types not known in Europe. There our native laurels, rhododendrons, etc., won great favor and today the agaves and opuntias impress one as having always belonged to the Mediterranean district. To further penalize our neglect, we purchase from European nurseries thousands of dollars' worth yearly of young plants of our own native species. More recently American plants have been given larger recognition. Asters, goldenrod, columbines, hepatica, bloodroot, cardinal flower and many others are now generally cultivated; and perchance the day will come when our country places as well as our city parks shall be decorated with that glorious small tree — the dogwood. The world-wide trade in flowers and plants is enormous. In a recent American catalogue, fifty-two pages were used in listing flower seeds and one hundred and eighteen for ornamental plants, and our catalogues are as nothing in comparison with some of the European.

Man's growing mastery and his interest in flowers is well shown by the increase in the varieties. From the three species of dahlias native to Mexico have come over eight hundred varieties known to commerce. From one or two peonies of Chinese origin the Europeans have in one century developed some hundreds of varieties. In a few years, by careful crossing, the canna in addition to having beautiful leaves has developed enormous flower heads. The improvements thus secured show in size,

color, length of flowering period and manner of growth and perfume. It will be noted that the list of ornamentals is far longer than the one of food plants. Here personal likes play a larger part and uniformity is not so necessary.

Quite as important as man's control of plant life is his domestication of animals. Here also the beginnings go back beyond our records. The search for the originals of our domestic animals is complicated by several factors: (1) we are ignorant of the amount of variation since domestication; (2) we lack definite records as to place of domestication; (3) the fact that many different wild species are known to have existed. Practically all of the larger mammals were represented in Europe and in Asia. It seems very probable that centers of domestication are to be sought on both continents whence the domestic forms were scattered and later interbred in endless variety.

Bird life is peculiarly valuable in warm lands where meat will not keep long. Geese were kept in ancient Egypt and the art of incubating eggs in manure was apparently understood. Ducks were first domesticated in the East by Chinese; in the West by the Romans. Chickens were unknown to the peoples of classifical antiquity. Homer and Hesiod never mention the hen nor do the older parts of the Old Testament. Yet Cæsar found the chicken in southern England. It was scattered through Europe by the Germans, if we may judge by the similarity of the name in all the old European languages. It was brought from northern India in the Medo-Persian campaign and gradually became known about the Mediterranean. It is a descendant of the bankiva or jungle fowl. Now it has spread all over the earth. From Africa came in olden time the guinea hen. The pea fowl of

India during the Middle Ages was valued highly for the table; now, as an ornament only. Hawks, falcons and other birds once were kept in large numbers, but now relatively few are esteemed worth the trouble. One recent addition to the list of which Americans boast is the turkey. The ostrich was not kept until the middle of the nineteenth century.

Of four-legged beasts not a single one of any special importance has been domesticated within historic time. The horse, cattle, ass, camel, sheep, goat and pig were in bondage when our records begin. These have generally been the most important, though not known to all the groups of men. Aside from these, the reindeer in Arctic regions, the elephant in India, the llama (kept by the ancient Peruvians in herds of thousands on the mountain pastures of Lake Titicaca) and the water buffalo in Asia are most noteworthy.

The dog has been one of the best loved and least useful companions of man throughout the ages. He seems to have been domesticated in many quarters of the earth. The first traces of dogs are found in the kitchen middens of Europe and somewhat later in the pile dwellings of Switzerland. These are small dogs, on the order of the terriers. At first the type is very uniform and no marked variations are found till the end of the later Stone period. By the end of the Neolithic era came the large dogs of the mastiff type. Various species of jackals and wolves probably have been tamed in divers sections of the earth. Apparently the first dogs were of jackal descent. Keller believes that the shepherd dog is descended from the Indian wolf. "It is easily demonstrated that the original home of the great 'dogge' is to be found in the highlands of Thibet. They became established in Europe at the time

of Alexander the Great, and appeared in our Northern Alps at the beginning of the first century, where they were distributed by the Romans." [5] The grayhounds are descendants of the Abyssinian wolf.

The only people, so far as we know, who domesticated the cat were the Egyptians, who paid it high honor. They had tamed it at least 1300 years before Christ and had portrayed it on their monuments for the thousand years preceding. The history of the long-haired Angoras is not known. They appear to have come from Central Asia. It is likely that these strains have not only been crossed with each other but also with the common wild cat of Europe. The cat was not largely kept outside of Egypt until the later days of the Roman empire, even though Greece and Rome had been plagued by mice whose name indicated a thief and whose natural enemy is described as the weasel. It spread to Italy about the fourth century of our era and to the balance of Europe by the sixth. About the time of the German invasion of Europe there came in from Asia the common gray rat in great hordes. Thenceforth cats were more highly esteemed, so some think. The more savage brown rat arrived on the scene early in the eighteenth century, driving out the gray rats and giving the cats added employment we may assume. The cats of today are not great rat catchers, while the damage done by them to bird life is a serious matter.

Man has brought about another serious problem by his attitude toward the domestic cat. In many cases he permits it to become wild and the result is a great destruction of bird life estimated for states like Illinois at 2,500,-

[5] KELLER, C. Derivation of European Domestic Animals in *Report of Smithsonian Institute*, 1912, p. 483 ff.

000; and New York, 3,500,000 yearly. There are a large number of such stray cats and they probably are more destructive of bird life than any native wild animals in the eastern United States. They also form the greatest obstacle to the rearing of game birds in captivity. While we may be very fond of puss as a pet, the neglected cat must be destroyed. It is also probable that disease is not infrequently transmitted by them to their owners.

Cattle were early tamed. They certainly were kept by the Assyrians. Keller thinks that the banteng, which still exists wild, is the original of the Asiatic and of the European small, short-horned races; but some hold that the aurochs, "the Celtic shorthorn," is the original of the short-horned or hornless smaller breeds. It is probable that in Europe the urochs (the urus of Cæsar which survived till the twelfth century) or a closely related southernly form was the ancestor of the long-horned heavy cattle.

The ass was common to Asia and Egypt, and was kept from the end of the bronze period. The first domestication seems to have been in Egypt by the Hamites. It came early to Europe but was used in agriculture only on the Mediterranean.

Swine were kept in very ancient times, both in Egypt and Greece, while Chinese records go back to the fourth century B.C. The east Asiatic banded pig species was transferred to Europe in prehistoric times and has been largely kept in south Europe. In north Germany and Bavaria there are strains descended from the narrow backed native pig.

Tame camels were known in Assyria in the ninth century B.C., but were not kept in Egypt. The camel and

dromedary appear to have a common ancestry in the Asiatic stock. Their distribution, says Keller, was "relatively late."

Species of horses were once common in Europe and Asia and there is much uncertainty as to their share in present breeds. The European forest horse was apparently the ancestor of the calm, heavy strains; while the Celtic horse is represented by the type known to Americans as the Shetland pony. The only wild horse known to us today (the e. przewalski of the desert of Gobi, once common in Europe) became the founder of the slender, nervous, Arabian type. Possibly there is another common ancestor of the last, but this is uncertain. In any case, the horse was first domesticated in Asia. The horse was pictured on Egyptian monuments as early as 1575 B.C., and Egypt was *not* its habitat.

The bezoar goat of west Asia was early tamed and came to Europe via the Ægean Islands and was kept by the oldest lake dwellers. The wool sheep reached Europe in Mycenian times from east of the Black Sea. The African maned sheep was nearly domesticated in the Nile Valley. These Asiatic and African forms, Keller thinks, reached Europe via Crete in the days of the old civilization there, 2000 or 3000 years B.C.

Man uses these animals for various purposes: (1) companions, (2) food, (3) clothing, (4) transportation and (5) draft. Some animals combine many of these functions. The dog is a valued companion; is sometimes eaten or used to hunt other animals; provides clothing and in snowy countries is valuable for traveling. With reference to these uses animals vary greatly. By mating those showing the qualities desired, we have secured different types of horses from the heavy, slow Morgan of great

strength to the slender high-strung Kentucky thoroughbred. We have cattle producing large amounts of milk (Holstein) or a small amount of very rich milk (Jersey) or valued chiefly as beef (Shorthorns). We have chickens like the Asiatics (Brahmas), heavy birds, rather poor layers, but good mothers, gentle and rather sluggish; or the European breeds (Leghorns, Minorcas), small and so active that no fence stops them, excellent layers, but poor sitters and of little value for the table. By various combinations we have produced the American breeds (Rocks, Wyandottes, Rhode Island Reds) of medium size and combining in large measure the egg-producing qualities of the Mediterranean with the weight and disposition of the Asiatics. Moreover, we can have these birds in several colors: barred, white, buff, or with single, pea or rose combs. The sheep may be valued for mutton or wool.

Endless experiments are being made in crossing animals, and there is every reason to anticipate greater development in the future. We have long valued the mule, the hybrid resulting from mating the horse and ass. Mules are, however, infertile. It may be that by crossing the zebra with the horse, we shall find a new type that will prove fertile. Such crosses are now known, but their worth is yet to be determined. Perchance we shall get a new type by mating the bison with cattle that will be worth while. Crosses of cattle with some of the humpbacked cattle of Africa in the southwest seem to promise an animal immune to ticks, which will be of great importance. In other words, we are now producing species, some of which we must discard, others we shall keep.

Of the vast horde of insects, there are two that have been of unusual value to man. The mulberry silk worm,

according to Chinese records, was kept as early as 2640 B.C., when the Empress Si-Ling encouraged the planting of mulberry trees and the culture of the worm. It reached Japan via Korea in the third century of our era. Somewhat later it was taken to India, thence to Persia. Aristotle was the first Western writer to mention it. At the beginning of the Christian era raw silk was well known in Rome and was worth its weight in gold. Justinian sent an embassy to China which brought some worms back in a hollow bamboo rod A.D. 550. These formed the basis of supply for the Western world for many years. According to the Encyclopædia Britannica the world now produces some 42,000,000 pounds of raw silk yearly: China with 13,000,000; Japan, 11,000,000; France, 1,276,000, being the chief sources of supply. To the sum total the United States as yet makes no contribution, owing largely to the high cost of labor.

The keeping of bees also antedates our records. They were as highly prized by the classical people as they are today by numerous savage tribes. Several species are used, one of the commonest being the dark-colored European bee. The Spaniards appear to have introduced the bee into Mexico in early days. It reached Pensacola by 1753, New York by 1797, and was known west of the Mississippi by 1797. The last century has witnessed a great change in the methods of culture. The old straw kep has yielded place to the modern hive. Most important is the use of some comb foundation. Apiaries of two to three thousand colonies are now reported. Over 100,000,000 pounds of honey are used yearly in the United States.

The conquest is far from complete. Birds and mammals to some extent are domesticated. Beginnings are

being made in the cultivation of the forms of life in water. We now care for the oyster beds. Fishes are hatched by the millions at fish hatcheries and suitable waters are stocked therefrom. This entire industry is just at its beginning, and has enormous possibilities.

How can any one overestimate the benefit of domestic animals to man? By their milk or meat he has been fed. By their skins and fur he has been clad. Their speed has rescued him from danger; their strength has plowed his fields and pulled his implements. With their ligaments he bound his primitive weapons together. From their bones he made his tools and handles and began perchance his first attempts at making images. From them he learned many of nature's lessons. It is not too much to say that without domestic animals civilization is hardly possible. Some groups like the Chinese and Japanese have attained high culture to be sure, with little use of animals, but at what cost? The great poverty of the mass of the people is the answer. The absence of suitable animals alone goes far towards explaining the relative backwardness of the Indian as compared to the European.

Man has been slow to realize that it does not always pay him to keep a cow merely because it gave milk. In part this has been due to ignorance, in part to the difficulty of discriminating, in part to the added expense involved in more careful methods. We may see just what this means by glancing at the dairy cattle in the United States. It is estimated that some 21,000,000 cows are kept which require for maintenance an area about equal to the state of Illinois. Estimating that a dairy cow which does not yield yearly 4,000 pounds of milk containing 160 pounds of butter-fat is kept at a loss we may

divide the cattle into three groups each containing 7,000,000 cows. The actual results are as follows:

*Uncle Sam's Three Herds of Dairy Cattle*

| | *Pounds milk yearly* | *Butter fat* | *Annual profit* | *Annual loss* |
|---|---|---|---|---|
| 1st 7,000,000 ..... | 3654 | 134 | .... | $7.25 |
| 2nd 7,000,000 ..... | 5000 | 198 | $7.85 | .... |
| 3rd 7,000,000 ..... | 6765 | 278 | 26.82 | .... |

The first herd is kept at an actual loss of $7.25 per cow, while the first and the second herd combined yield a profit of only thirty cents each and the cows of the second herd must be milked 82 times for each dollar of profit. The third herd is really the only profitable one. When such facts are fully realized we may anticipate marked improvement in the quality of cows kept.[6]

In at least one other way hitherto unmentioned are animals helping man. This is with reference to germ diseases. The beginning may be dated in the last decade of the eighteenth century when Edward Jenner, noting the pure complexions and smooth skins of the milkmaids wondered if the chance infection with cowpox prevented their taking the dreaded smallpox. Experiment proved this to be true. Now with the elimination of cruelty and needless suffering investigators the world over are trying experiments upon lowly forms of life to see if in some way control may be gained of the germ diseases which cause so much suffering and death among mankind. The results have been wonderful.

In the natural world there is no such thing as natural death in the sense of the long sleep coming after a long life with the gradual weakening of the vital powers. Death is the result of accident or assault by some foe in

[6] FRASER, W. J. Three Herds Dairy Cattle, *Rev. of Rev.*, March, 1915.

numbers large or small. Now that the large animals are overcome man is tempted to boast of his conquest, forgetting that today his dangerous enemies are the minute forms of life. The discovery of the causes of zymotic diseases and the various methods of fighting them makes the contest hopeful.

Soon after the microscope came into use in the seventeenth century, Leeuwenhoek (1687) discovered the minute one-celled plants known as bacteria. In 1762 Plenciz, a physician of Vienna, suggested that diseases were due to such animalcules, each disease having its own. This theory had some vogue; but no one seems to have tested the suggestion so the idea quickly died out. In 1837 an Italian, Bassi, discovered that the disease killing the silk worms was apparently caused by "minute glittering particles" of matter that passed from the sick to the healthy. About 1860 Pasteur found germs in the air. In 1849 Pollender saw rod-like forms in the blood of cattle afflicted with anthrax, but it was not till 1863 that Davaine proved that these were the cause of the disease. In 1880 Eberth identified the bacillus producing typhoid. In 1881 Koch found the bacillus of tuberculosis and in 1883 that of Asiatic cholera. The next fifteen years brought the discovery of the causes of many of the common diseases. The last fifteen have been less productive, with some notable exceptions, such as the solution by Noguchi of the cause of rabies in 1913. It is thought that the relatively few recent discoveries may be due to the fact that the undiscovered germs may be too small to be found with present instruments and methods. It is claimed that we know some 1500 varieties of germs, of which some 50 are causes of disease.

At first these discoveries were received with extreme

credulity even by medical men. But the tests self-imposed by Koch left little doubt. He stated that before we could be sure that a given germ was responsible for the disease it was necessary, (1) to find it present in large numbers in every case, (2) to take it and make a pure culture in some substance, (3) to inoculate a subject with the pure culture and produce the disease, and (4) to find again large numbers of the germs in the inoculated subject. Today it is generally believed that all the diseases we call contagious or infectious are caused by minute organisms. Other forms of disease, affecting the individual only, result from shock or injury, from the presence of some chemical due to defective metabolism, or from some parasite like the tapeworm.

Inasmuch as these zymotic (germ) diseases are produced by plants and animals, it is possible to study them, learn their life histories and thus take measures to prevent their spread or to fight them in the body of the sick animal or person. With few exceptions there are no specific cures for these diseases, that is we do not have substances which we can use in such fashion as to kill the germs causing distress to the human body without killing the person. To this statement there are today a few exceptions, true in most cases at least: malaria can be cured by quinin; iron overcomes certain types of anemia; while syphilis yields to arsenic and pyorrhea to ipecac. It may be that future research will reveal other such specifics.

Knowing the nature of the causes gives man other avenues of attack. Inasmuch as given plants use certain elements as food, it must follow that those elements in a given person may be exhausted. If then some similar organism can be found whose after-effects are mild, the soil may be rendered unfertile for the dreaded disease,

which cannot develop thereafter even if it finds entrance. Or, it may be that the poisons produced by such related forms destroy the later comers. We have not yet discovered the germ of smallpox, but the milder cowpox gives almost complete immunity. In other cases we use the self-created poisons above mentioned (called antitoxins) and, by injecting these into the system, as in diphtheria, destroy the disease.

To tell the story of man's failure and success in the battle with disease would require many volumes. We can only give a few illustrations here and indicate future possibilities. In 1867 Lister, seeking to cut down the terrific death rate following surgical operations, used carbolic acid with surprising results, and thus started modern antiseptic methods. Anesthetics had already been introduced. Ether was first used by an American physician, Dr. C. W. Long, in 1842. It came into general use in 1846 and in 1847 chloroform was employed. Thanks to these and present methods of operating, openings of the head, chest and abdomen which were considered almost necessarily fatal in 1870, and only done when death was otherwise certain, are now practically without danger.

The mortality of ovariotomy formerly 69 per cent is now 2 per cent. The mortality of compound fractures formerly 60 per cent is now 3 per cent. The mortality of major amputations formerly 50–63 per cent is now 10–20 per cent.

For many years the death rate of women at the time of childbirth was most puzzling. "Le Fort, in his railing accusation against the lying-in hospitals of France, which appeared in 1866, calculated that 30,394 deaths from puerperal fever had occurred in the 888,312 women delivered in the hospitals of Paris up to the year 1864 — an inci-

dence of 3.5 per cent, or one death to every 27.2 labors. Moreover, he stated that from 1860 to 1864, inclusive, the mortality in the Maternité of Paris was 12.4 per cent, which in December, 1864, rose to the colossal height of 57 per cent, while in the Clinique it averaged 14.7 per cent between the years 1833 and 1864, and on several occasions rose above 20 per cent. On the other hand, the mortality outside of the hospitals was much less, as only one woman perished out of every 212, which indicated that seven-eighths of the hospital deaths were due to conditions prevailing in them." [7] In Germany 3.4 per cent of those in hospitals died, but only .6 of those delivered at home. England showed similar conditions. In the United States the Pennsylvania Hospital had a record of 5.6 per cent from 1803 to 1833. In an epidemic at Bellevue Hospital in 1872 the death rate rose to 18 per cent. Today, thanks to antiseptic methods, the death rate in good hospitals is less than .25 per cent. Investigation revealed the fact that this death rate in the hospitals was due to germ infection. Once the fact was discovered, efforts were made to meet the situation with excellent results. Thus in 1909 the New York Lying-in Hospital lost only .34 per cent out of 60,000 obstetrical cases, or one out of 1250.[8]

Now that we understand the nature of diseases somewhat, our problem becomes one of prevention rather than cure. That vast unreasoning fear of disease which man had, and still has in part, largely disappears as we come to know the condition under which disease is dangerous. We know just how certain diseases are spread, hence we can safeguard ourselves.

7 Williams, J. W. Obstetrics and Animal Experimentation, p. 5.
8 Keen, W. W. Animal Experimentation, p. 256.

Perhaps the most conspicuous triumph of men in this field is the conquest of smallpox. Two hundred years ago about one-tenth of our ancestors died of this disease and "a pox upon you" was one of the common curses. It is estimated that from 80 per cent to 90 per cent of the population had smallpox at some time during their lives and few faces even among the royal families were not pock-marked. In 1722 the town of Ware, England, contained 2,515 inhabitants of whom 1,601 had previously had smallpox. An epidemic came and only 302 were left untouched. In Iceland in 1707 some 18,000 or 60 per cent of the total population of 30,000 died in one epidemic. In 1752 Boston, England, had a population of 15,684 of whom 5,998 had survived an earlier attack. An epidemic came and some 5,545 contracted the disease, 2,124 were inoculated with it following a custom which had been developed in Turkey in the effort to overcome the disease. Deducting those who fled, only 174 remained who had not been sick. In Montreal in nine months of 1885 some 3,164 died in one epidemic. With the nineteenth century came vaccination with the virus of "cow-pox" and the steady disappearance of the disease. The facts are clearly shown by the condition in the different countries. In the years 1893 to 1897 smallpox caused the deaths of some 275,502 in Russia, while in Germany only 274, thanks to a good system of compulsory vaccination. During this period Spain lost from smallpox 563 per million; Russia, 463; but Germany only 1, and Germany has had no epidemic since 1874. At the time the Americans entered the Philippines it is stated that there were in five provinces some 6,000 deaths yearly from smallpox. In 1905 and 1906 some 3,000,000 vaccinations were made and in the following year there were no

deaths from the disease. Yet today misguided individuals would persuade us that vaccination is useless and dangerous. Dr. Schamberg reports that in 6,739,902 cases there were only 476 deaths which by any stretch of imagination could have been charged to the vaccination, a rate of .007 per cent. In the 3,500,000 vaccinations in the Philippines there were no deaths and no serious infections. From 1901 to 1905 some 500 persons in Philadelphia died of smallpox, but not one of these had been successfully vaccinated within ten years. It is not too much to say then that smallpox is vanquished if man so chooses. The financial gain can be seen from the estimate that the epidemic of 1891–1892 cost Philadelphia alone over $21,000,000, while the total cost of vaccinating, disinfecting stations, public instruction, etc., at the same time was some $750,000.[9]

In the United States we are probably safe in saying that the danger from those great scourges Asiatic cholera and bubonic plague is very small in view of our present knowledge. "Epidemics of both have occurred elsewhere in which more than a quarter of a million persons were attacked and nearly half as many were killed. In the single year 1885 cholera cost Japan a hundred thousand lives and inflicted a loss that could not have been less than two hundred million dollars. In the city of Hamburg the cholera epidemic of 1892 destroyed eight thousand lives and cost that commercial city twenty-five million dollars or more." [10] In the fourteenth century the bubonic plague under the title "Black Death" swept over Europe destroying some 25,000,000 people, or one-fourth

[9] SCHAMBERG, J. F. Vaccination in Relation to Animal Experimentation, 1911.

[10] MAYO, E. The Cost of Disease, *The Outlook*, May 13, 1911.

of the total population. During three months in 1911 some 50,000 died of it in Manchuria. So far as is known every person stricken with the disease died. In the four days ending December 27, 1912, some 1,714 deaths occurred at Mecca from cholera with over 10,000 pilgrims present in the City.[11] The battle with this enemy, which increases so fast that at the end of twelve hours one germ is reported to have become 17,000,000, and is so small that it takes 625,000,000 to cover a square inch, is not over but the outlook is hopeful. Thanks to an American, Dr. Richard P. Strong, we now know that both forms of the disease are caused by a bacillus which lives in a small fur-bearing animal of Manchuria, the tarbagan. If transferred to a person by a flea or by chance inoculated in some other way, it becomes the dreaded bubonic plague. If however it reaches the lungs it is the pneumonic plague.[12] By destroying the animals such as rats and squirrels from which it might be passed to man, the medical authorities were able to stop the epidemic of 1909 at San Francisco. Here then is a case when knowledge gives only partial control, but it is unlikely that Europe or America will ever endure again the plagues of the Middle Ages. It is now possible to secure some immunity against bubonic plague. "A large series of numbered prisoners were confined in a jail where plague prevailed. Those who bore even numbers were inoculated, while those having odd numbers were not inoculated. Among the uninoculated there occurred ten cases of plague, six of which were fatal; while among the inoculated there were three cases, all very mild and all of the patients recovered." [13]

[11] New York *Independent*, Jan. 9, 1913.

[12] Fighting the Black Death, *World's Work*, Dec., 1913, p. 219.

[13] McCoy, G. W. Relation of Animal Experimentation to Plague, p. 9.

Recently, 45 per cent of those uninoculated died, and but 17 per cent of the inoculated.

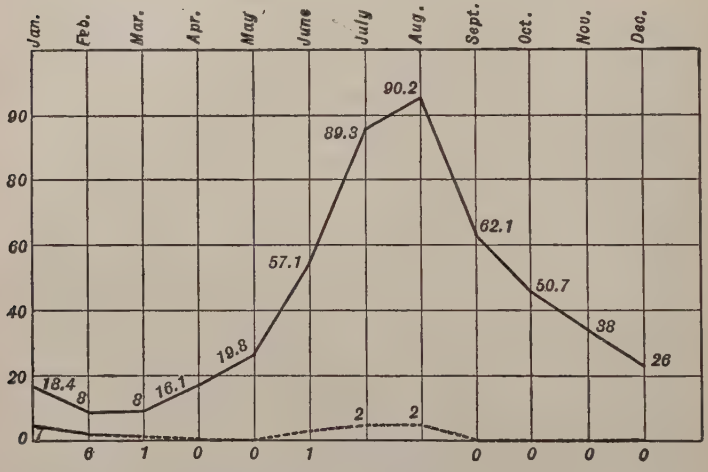
One of the greatest discoveries of the ages was made in 1900 by Dr. Walter Reid of the United States Army when he found that yellow fever was given to man through the bite of the female stegomyia mosquito. We now know that this mosquito must bite a fever-stricken patient within the first three days of his illness. Then for some twelve days the germ incubates in the body of the mosquito and may thereafter be transmitted to man. This germ chances to be animal. At once the yellow fever patient ceased to be considered a direct source of danger. He must be so screened that no mosquito could get at him, for in no other fashion can he pass on the disease.

Yellow fever kills about 25 per cent of those attacked. Its native home appears to have been the shores of the Caribbean and the southern coast of the Gulf of Mexico. After the appearance of the Europeans the sailing ships carried it to Havana where it became endemic after 1762. It was taken to Africa by 1494 and is there endemic on the West Coast. It is now endemic in the Western Hemisphere as far south as Rio Janeiro and as far west as Vera Cruz.

During the nineteenth century the deaths from yellow fever at Havana had frequently run as high as 1500 per annum, or at the rate of 428 per 100,000; but they stopped abruptly and absolutely in 1902. The record from 1890 follows:

| | | | |
|---|---|---|---|
| 1890 | 308 | 1896 | 1282 |
| 1891 | 356 | 1897 | 858 |
| 1892 | 357 | 1898 | 136 |
| 1893 | 494 | 1899 | 103 |
| 1894 | 382 | 1900 | 310 |
| 1895 | 553 | 1901 | 18 |

The marked drop in 1901 shows the significance of Dr. Reid's discovery. The following diagram is also suggestive:




MORTALITY YELLOW FEVER — HAVANA
Monthly Average for 20 Years Preceding 1900. Lower Dotted Line Shows 1901 Mortality

In 1793 in Philadelphia 4,041 out of a population of 40,144 died of yellow fever between August and the middle of September. When the epidemic of 1878 struck the southern cities people fled by untold thousands, and the cost is estimated at $100,000,000 not to mention the loss by death. In 1905 this would have been repeated had it not been for the discovery of Dr. Reid and his associates. General Leonard Wood is quoted as saying that this discovery saves the world each year more than the entire cost of the Cuban war.

In 1880 Laveran found the microbe which causes malaria, and in 1898 an English physician, Dr. Ronald Read, discovered that this organism must pass part of its life in

a female mosquito of the Anopheles species and by it be transferred to man. It is claimed that in parts of the United States today malaria reduces the working strength of the people 50 per cent. Sir Ronald Ross of the Liverpool School of Tropical Medicine is quoted as saying that one-half of the people of Greece have suffered genuine injury from malaria, while Dr. W. H. S. Jones feels that malaria in no small way caused the downfall of ancient Greece and Rome. Continued warfare on the mosquito therefore will give us the victory over both malaria and yellow fever.

The work done at Havana and at Panama is a striking proof of man's growing control and of its value. The Panama Canal was made possible by the growth of our knowledge of disease. No one can speak with greater authority on this than Dr. Gorgas. Before 1901 "Havana had yearly from 300 to 500 deaths from malaria, rising as high in 1898 as 1,900 deaths. Since 1901 there has been a steady decrease in the malarial death rate until the last year of the table, 1912, when there were only four deaths." "By 1912 malaria had become as completely extinguished in Havana as had yellow fever in 1902." [14] In 1906, at Panama 821 out of every 1000 were admitted to hospitals for malaria, in 1913 only 76 per 1000. Of the general situation at Panama he says: [15] "We had an average of 900 men sick every day. For the year this would give us 328,900 days of sickness, and for the ten years 3,285,000 days of sickness. If our rate had been 300 per 1000, a very moderate figure compared with what it was under the French, we should have had 11,700 sick every day. For the year this would have

[14] GORGAS, W. C. Sanitation in Panama, pp. 73, 74.
[15] Ibid., p. 275.

given us 4,270,500 days of sickness and for the ten years 42,705,000, a saving of 39,420,000 days of sickness during this period." This is equal to a saving in cash of $329,420,000.

"During the ten years of construction, we lost by death seventeen out of every thousand of our employees each year. That is, from the whole force of 39,000 men, 663 died each year, and for the whole construction period we lost 6,630 men. If sanitary conditions had remained as they had been previous to 1904, and we had lost as did the French, two hundred of our employees out of each one thousand on the work, we should have lost 7,800 men each year, and 78,000 during the whole construction period." [16] This means that 71,370 lives were saved.

Perhaps the greatest conflict of medical history is that now waged against tuberculosis, which today causes over one-tenth of the deaths in our land. This disease is important not merely because of the death rate (being responsible for some 130,000 lives annually) but because of its long, lingering character, imposing a terrific burden upon families and communities alike, and costing some $200,000,000 annually in our own country. Cures for tuberculosis are today unknown, yet the newer knowledge has enabled us to cut down the death rate perhaps 50 per cent in the last twenty-five years. Once regarded as fatal to every sufferer, we now know that if proper care is provided in the earlier stages of the disease, recovery may be expected in perhaps the majority of the cases. No less an authority than Dr. Earl Mayo has declared: "If the members of the medical profession were given a free hand to deal with this disease, backed by adequate provision for the care of existing cases, tuberculosis could be prac-

[16] Gorgas, W. C. o. c., p. 280.

tically stamped out within a single generation." [17] The fight against this disease involves its extermination among cattle likewise, for these valuable animals are unfortunately attacked by it. Probably the best organized social agency of the day is the anti-tuberculosis movement.

For a long time typhus and typhoid — both filth diseases — were not distinguished. The rôle of the former is now usually insignificant, but recent frightful outbreaks in Servia and Armenia make us realize that it is only suppressed by maintaining high standards.

*Deaths per 10,000 from Typhus and Typhoid*

| | | | |
|---|---|---|---|
| 1838 | England ..... | 12.28 | |
| 1858 | England ..... | 9.18 | |
| 1878 | England ..... | 3.06 typhoid | .36 typhus |
| 1892 | England ..... | 1.37 | .03 typhus |

Typhoid fever, the cause of the death of 30,000 Americans a year, did not play an important rôle till the middle of the nineteenth century, when the many epidemics became noticeable. It is spread only through the waste products of the body and carried by milk, water, or flies to other persons. If these waste products are sterilized there can be no spread. Hence the bill of $212,000,000 annually paid by Americans is wholly unnecessary if present knowledge is utilized. Europe is ahead of us. Thirty-three of its largest cities with a population of 31,500,000 have recently averaged only 6.5 deaths to every 100,000, while twenty-five of our cities with 20,000,000 inhabitants are averaging 25 per 100,000. Aside from this attack on the disease, we are now reducing its ravages by inoculation. In 1898 in the Seventh Army Corps at Jacksonville, Florida (some 10,759 men), there were 4,422 cases of typhoid with 248 deaths. In the 1912

[17] Mayo, E. In *The Outlook*, Dec. 7, 1912.

maneuvers at San Antonio, Texas, among 12,801 soldiers there was only one case, which however resulted fatally.

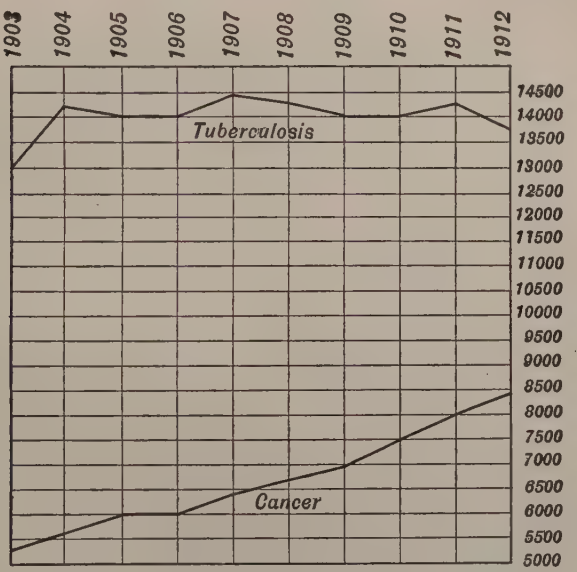
"During the Spanish War there were 20,738 cases of typhoid and 1480 deaths; nearly *one-fifth of the entire army* had the disease. It caused over 86 per cent of the entire mortality of that war. In some regiments as many as 400 men out of 1300 fell ill with it. . . . From June 1908 to 1909, when the vaccination was purely voluntary and the army was not in the field, proportionately *sixteen times* as many unvaccinated soldiers fell ill with the disease as compared with the vaccinated." [18] In the British garrison in India formerly from 300 to 600 died yearly of typhoid before vaccination was introduced. In 1913 less than 20 died. Among 8,754 inoculated British soldiers in India there were recently 16 cases with no deaths, while 7,376 uninoculated showed 68 cases with 14 deaths. The French have produced similar results in Africa. Contrast the Franco-Prussian War, when typhoid was responsible for nearly 60 per cent of the mortality among the German troops, with the Russo-Japanese War when for the first time in history disease played second rôle to death in battle.

Diphtheria still kills about as many as typhoid, and these chiefly young children, but its share in the death rate has been greatly decreased since the discovery of antitoxin in 1892 by Behring and can be still further reduced when better provision is made for prompt attention. The death rate from diphtheria in New York City is now about one-fifth of the average rate before the introduction of antitoxin. In 19 of the large cities of Europe and North America with a combined population of nearly 23,000,000, the deaths from diphtheria were 66.9 per

[18] KEEN, W. W. o. c., p. 259.

100,000 in 1890; 32.7 in 1900, and 19 in 1905. The mortality of 7.9 per 10,000 of population in 1894 was reduced to 1.9 by 1905.

With reference to other diseases, the present prospect is less encouraging. Pneumonia contests with tuberculosis for a place at the head of the causes of death, while cancer stands seventh and is apparently increasing. While we are making little headway against pneumonia,




DEATHS FROM TUBERCULOSIS AND CANCER

the fact that it attacks people of advanced years and the intemperate makes it perhaps less significant. It results fatally in from 20 per cent to 30 per cent of the cases. The germs are probably present in 20 per cent of healthy normal people all the time. Cancer is giving us growing concern. The use of the knife in the early stages plus perhaps treatment by radium, offers the only hope at

present. The cause of cancer is unknown, but it is generally believed to be a germ of some sort. The recent hopes based on the announcement from some of the best men in America and France that cancer is yielding to radium treatment are now being surrendered. Whether this proves true or not it is believed that sooner or later its secret will be revealed. It is claimed that each year in Germany more women die of cancer than there were men killed in the whole Franco-Prussian War. The chart on page 141 shows that we are controlling tuberculosis while cancer is steadily increasing. The figures are from New York.

A world-wide war has been declared on disease. The dreaded sleeping sickness which has depopulated Uganda, the anemia which makes wrecks of the natives of Porto Rico and the tropics, the hookworm disease which came to America with the slaves from Africa are better understood and are being conquered. The movement inaugurated by the chemist Pasteur has revolutionized the function of medicine and the doctor with his "pill for every ill" yields place to the research student who strikes at the source of disease.

This new warfare uses several methods as has been indicated. In a few cases long experiment reveals some agent or compound like salvarsan (arsenic) discovered by Ehrlich and first known as No. 606 (that number representing its order in his experiments), which in most cases kills the germ of syphilis. In the second case we use modified forms of the disease or its own deadly by-products to bring about its prevention or destruction, and finally we endeavor to prevent infection by destroying the germs just as we have destroyed the great auk.

Beside the doctor to whom we go voluntarily in sick-

ness has arisen the medical officer of the state backed by law to safeguard public health. State commissioners of health or boards of health supervise matters within the state. Since 1893 all maritime and interstate quarantine powers of the national government are controlled by the Public Health Service under a supervising surgeon general. This service establishes quarantine regulations for all ports of the United States and has gradually taken over control of the ports, maintaining now some fifty stations in addition to those on the Islands and in Alaska. So recent has this development been that the ports of Boston, Baltimore and New York are still under local control. So little anticipated were these functions that even today if a serious epidemic breaks out in some state the national authorities can only interfere if there is danger that interstate commerce *in goods* will be affected.

Meantime great research laboratories have grown up in connection with city or state departments, in medical schools, or special institutions like the Rockefeller Institute for Medical Research in New York City, or the Pasteur Institute at Paris. Chairs of tropical medicine are found in our schools and special public health courses appear in the curricula. The doctor has joined forces with the social worker and the demand is that preventable disease shall be no more. In no period of earth's history has so much been accomplished as in the last fifty years. Small wonder that man is encouraged to hope that a real and effective control of these natural enemies will soon be in his hands.

In many ways quite as important as the control of diseases affecting man is that of those destroying his plants and animals, for they too are subject to attack. Tuberculosis has already been mentioned in this connection,

and from one-third to one-half of our cattle are said to be infected. Borna's disease, a form of meningitis, destroyed some 20,000 horses in a few weeks in 1912 in Kansas and adjoining states. The cattle plague (Rinderpest) has repeatedly destroyed the herds of the Herero Negroes and it is stated that probably not one in ten thousand wild buffalo in west Africa and Uganda survived the last epidemic some twenty-five years ago.

The financial loss entailed by disease among domestic stock is enormous as our government reports reveal.

*Live Stock — Losses from Disease in United States*

| | |
|---|---|
| Hog cholera | $75,000,000 |
| Texas fever and cattle ticks | 40,000,000 |
| Tuberculosis | 25,000,000 |
| Contagious abortion | 20,000,000 |
| Blackleg | 6,000,000 |
| Anthrax | 1,500,000 |
| Scabies of sheep and cattle | 4,600,000 |
| Glanders | 5,000,000 |
| Other diseases | 22,000,000 |
| Parasites | 5,000,000 |
| Poultry diseases | 8,750,000 |
| | $212,850,000 |

Considering three of our common food animals we find a reported loss in 1913 in the United States:

Swine, 119 out of every 1000 or 7,005,000 from cholera chiefly
Cattle, 19 out of every 1000 from diseases
Cattle, 10 out of every 1000 from exposure
Sheep, 42 out of every 1000 or 1,737,000 from disease and exposure
Total money loss ..... $150,000,000

Some 200 insects attack domestic animals in this country. If we are to protect ourselves from great loss as well as from disease, we must control the fleas, flies, ticks, and other germ-carrying forms. By a direct warfare on ticks we have checked the spread of such diseases as "Texas-fever" among the stock; and the Bureau of Ani-

mal Industry was able to report in 1914 that 30 per cent of the territory formerly cursed by ticks was free from them and the quarantine lifted. Ten per cent of the calves in some regions were formerly lost through blackleg. Now by the use of a virus the loss is less than .5 per cent. Sheep scab and cattle mange are now eliminated on 135,000 square miles formerly quarantined. We have recently discovered that tapeworm cysts are rather common in sheep and we shall have to guard against a possible infection of human beings. About 160 persons die of rabies and the Pasteur Institute treats some 1500 patients each year. If we are to rid ourselves of this dread disease we must stamp it out in the animals. The epidemic of "foot and mouth" disease of 1914 and 1915 did enormous damage, compelled the destruction of valuable herds of stock and interfered with commerce and ordinary farm life in many ways. It was overcome by government action, otherwise we might have lost most of our cattle.

To these problems man has given great attention and veterinary science has rapidly advanced. The story of the man who applied to the government for advice as to treatment of the sick pig and was told how to cure it, while his neighbor was informed that the government could give no aid to his sick wife, really illustrates the relative attention given by our national government to the welfare of plants and stock. Disease-resisting plants have been found or developed. The farmer may get numberless pamphlets and volumes free by request from state or national agricultural departments. The transportation of plants and animals even between the different states is carefully regulated lest disease be carried. In the fall of 1913 the importation of potatoes from certain foreign territory was suspended because of disease there, and similar pro-

hibitions frequently prevail. In 1916 the spread of the white pine blister rust began to threaten our pine forests and the importation of nursery stock from Europe was prohibited. These measures may not be adequately carried out in all cases, but they show that man has come to see the nature of his task in this regard and is determined to devise satisfactory methods of protecting himself and his. Let no one get the impression that man wholly controls the situation. The blight that is destroying our native chestnuts presents a problem which no man can yet solve. In Ceylon the coffee industry was entirely destroyed between 1870 and 1890 by a fungus which fed on the leaves of the bush.

We have now hurriedly surveyed three of the chief fields in which man's control of nature may be seen: (1) physical materials, (2) food plants and domestic animals, (3) diseases. By his control of materials and natural forces he drives his engines and constructs his machines and buildings. In limited areas he modifies temperature and protects himself against the weather. From plants and animals he gets his food and clothing. Hence he has spread over most of the earth and made himself at home. Of the higher forms of life he alone and those of the lower that he protects are increasing steadily. It is common to speak of his marvelous progress in control. It seems to me more correct to say that he has made some promising beginnings. Over wind and wave he exercises little mastery. The wonderful energy of the tides and the rays of the sun still await his call. The mass of element he rarely uses and the bulk of the forms of life are of little service, to say nothing of his controlling them for his purposes. Disease weakens his strength and that of his animals. Weeds hinder his agriculture. The point

is that viewing what he has done with the few powers he does employ his problem does not lie in any "niggardliness of nature," to use a favorite expression of the older economists, nor are we driven to think of any inability on his part. His power of creating wealth is steadily growing. He may continue to eliminate the harmful and increase the helpful forms of life indefinitely, so far as one can see.

The final tests of man's control are probably his own span of life and his death rate. It is claimed that the average life in Europe in the sixteenth century was from 18 to 20 years; today it is between 40 and 50. In the United States it is now 44 for men, 46 for women; in Sweden with regular gymnastics 50 for men and 53 for women; in India by contrast it is 23 for men, 24 for women. The death rate has likewise fallen. In the seventeenth century in London it was 50 per thousand, now it is 15. In Boston in 1700 it was 34, now it is about 14. In New York City in 1866 the death rate was 36; in 1913 only 14. The deaths in the same city for 1912 were 73,008, but had the death rate of 1866 obtained there would have been 188,000 deaths and 1,150,000 more cases of serious illness than there were.

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## CHAPTER IV

### THE EVOLUTION OF MAN

The real test of the scientific work of a man lies in the accuracy of his observations, not in the permanency of his explanations. Assuming that the observer has really seen that which he describes and has not been fooled by his senses, the record stands for all time. His attempt to explain the causes of what he has seen is limited necessarily by the general knowledge of his time. When he goes beyond this he merely guesses, and guesses are likely to be incorrect. Darwin's name will go down through the ages as one of the greatest scientists, yet every explanation and guess he made will probably yield place some day to others based on fuller and more accurate information than existed in his day.

Man has two methods of approaching his intellectual problems — speculation and research. Each of these has its advantages and dangers. Since there are several possible answers to most questions, speculation may possibly hit on the correct solution; or, as often happens, may stimulate the search for evidence. Research is much more exacting in its requirements and much more likely to throw out of court questions that have no standing. They speculated long in the Middle Ages as to the number of angels that could stand on the point of a needle, but research methods demanded of the student an ability to see angels that was lacking. Any given man is likely to combine these methods and, not infrequently, forget when he leaves the things he has seen and enters upon the dis-

cussion of the unseen. This habit causes his later readers great inconvenience, for it demands a knowledge of the author's background. To find Karl Marx, for example, in 1848 writing a Communistic Manifesto and objecting to the term *socialist* is quite disconcerting until the meaning of the term at that time is known.

So far as our minds can perceive, there are really very few ways in which life could have started on earth. It was either created by some outer power or else evolved because of the nature of matter. In either case it may have been an event occurring at one time, or a process lasting for ages. It appeared either as a simple or finished product, each variety of organism either related to or entirely distinct from other varieties. We have then in essence two main possibilities. Life was created (whether at one time or repeatedly, whether in the egg or the adult stage); life was evolved (whether at one time or repeatedly), or a combination of the two. That is, life was once created and has since evolved. Even the attempt to trace life on earth to other planets but removes the question one stage. All other suggested answers are but modifications of these.

If these facts be kept in mind we shall not be surprised that the ancient Greeks in their attempts to explain the world hit upon theories that are strikingly like some of the results of modern investigation. Some five hundred years before Christ, Thales of Miletus saw that eternal change characterized nature and thought that water was the principal element. His follower, Anaximander, asserted that living beings were developed from lifeless matter. In the mind of Empedocles (495–435 B. C.) these ideas took such definite shape that he has been called "the father of the evolutionary idea." "There are," said

he, "four elements — eternal, indestructible — Fire, Air, Earth, Water. These are acted upon by two forces: Love, which unites; Hate, which separates; and there arise by spontaneous generation living organisms; first plants, then animals." Curiously enough, Empedocles asserts that parts of animals precede the whole; heads without bodies, "eyes that strayed up and down in want of a forehead," etc., which combining produced monsters. These died, being unable to reproduce, and gradually more perfect forms replace them. Apparently there is here a vague idea of a struggle for existence and survival of the fittest.

The first student of natural history known to us was Aristotle (384–322 B. C.). In his "Physics and Natural History of Animals" we find that he knew some five hundred different species and was keen enough to see that sponges were animals. His study led him to the belief that purpose, law and design lay back of nature. He saw some of the facts of heredity and claimed that children inherited the characters acquired by their parents. He saw the coördination of the parts of the body with the accompanying division of labor. Life appeared to him as a function of the organism.

He thought that before the higher animals appeared there were soft masses of sexless germs. Apparently at times Aristotle identified these germs with mythological monsters. By spontaneous generation inorganic dust is changed to plants which have no feeling, later come animals endowed with sensibility. There is an inner perfecting principle which causes an evolution into the higher and more beautiful forms. Matter offers resistance to the forces shaping it, hence struggle is a natural process which results in progress. He rejected the implication of Em-

pedocles as to the survival of the fittest for he said that Empedocles believed in chance. Said Aristotle: "It rains not from chance, but from necessity." Had not his desire to emphasize the principle of law led him to reject this idea he would have outlined in all essentials the evolutionary theories of Darwin. Yet we must note the crudity and inconsistency of many of his ideas. Eels and flies might still arise from spontaneous generation. "Plants are evidently for the sake of animals and animals for the sake of man: thus Nature, which does nothing in vain, has done all things for the sake of man." [1]

It was not accident that led these students and many others here unmentioned to see that the beginnings of life were probably in water or slime. They dwelt by the sea and were familiar with the fact that it sheltered many of the lower forms of life. They believed that life originated in its lowest forms directly from the earth, that it changed by a process of evolution. With Aristotle we reach the culmination of Greek thought.

It is evident that the Greeks combined considerable knowledge of the actual world with very shrewd speculation. They had gained a conception of gradual change from the simple to the complex. Their ideas of cause and law were gradually extended to natural phenomena such as rain, storm, lightning and even to the action of the gods themselves. They were rapidly approaching the idea of a "reign of law." But the Greek nation was tottering, and soon to fall. The Romans were interested in other problems and the only one even to maintain this scientific attitude was Lucretius (50 B. C.) whom Clodd calls the "first anthropologist."

The oriental idea of an almighty God who sits on high

1 OSBORN, H. F. From the Greeks to Darwin, p. 52.

and directs the universe, whose will is law and whose acts are not limited by law replaces the Greek philosophy. The earth which the Greeks were beginning to conceive of as a globe becomes a flat surface. Above is the sky supported at the edges in some fashion by pillars. The sky is the solid firmament often thought of as made of ice. Somewhere above the sky is heaven. The stars are taken out of a closet and hung nightly in the sky by God. The lower side of the earth was the "antipodes" and later on there was much discussion as to whether this was inhabited. The fact that such beings would have their feet above their heads even if they did not fall into space settled this question in the negative. Somewhere further down was hell, whose glowing colors were often reflected in the evening sky when the sun had passed beyond the edge of the world.

The early Christians were too busily employed either in maintaining existence on earth or getting ready for heaven to pay much attention to nature. Gradually the canon of the Bible took form. Early in the fourth century Lactantius, who amusingly declared that man was so named because made from the earth, "homo ex humo," struck the note which dominated theology for fifteen hundred years. The statements of the Bible, literally interpreted, are to be the final authority in all matters. This conception was fastened upon the church by the man who marks the end of the old era as well as the beginning of the new.

Augustine (A.D. 354–430) sought to harmonize Aristotle with the biblical accounts of creation. He did not accept the statements of Genesis as exact and did not hesitate to explain them. Yet in his commentary on Genesis he wrote: "Nothing is to be accepted save on the author-

ity of scripture, since greater is that authority than all the powers of the human mind." [2] The origin of matter gave him trouble. Augustine said: "Although the world has been made of some material, that very same material must have been made out of nothing." [3] Hence all life developed out of nothing. He said further that the essence or seed of heaven, earth and life was created by God, not the finished product. There were two kinds of germs: (1) the visible, put directly by God into plants and animals, and (2) the invisible, which developed only under favorable conditions. "Certain very small animals may not have been created on the fifth and sixth days, but may have originated later from putrefying matter." [4] Man with his soul was the direct product of God, but other forms of life may have arisen gradually from the "casual energy and potency" of the seed. Independent and liberal as Augustine was, we find him holding to the conception that "all diseases of Christians" were caused by the devils common in the air, and interpreting the saying of Jesus "compel them to come in" "as a Divine warrant for the slaughter of heretics." [5]

After Augustine the appeal was not to evidence and observation, but to authority. If new facts appeared they were denied or explained in conformity with old beliefs. With few exceptions for over a millennium men in Europe did not question the principle established by Augustine, while fire and the stake silenced those who were obstinate. By an appeal to supposed truth man did his best to prevent himself from discovering the real truth

2 White, A. D. Warfare of Science with Theology, Vol. I, p. 25.
3 Ibid., p. 5.
4 Clodd, Edw. Pioneers of Evolution, p. 74.
5 Ibid., p. 75.

about the world in which he lived. Strange to say, the grim reality of this great struggle is dimly realized even today by the majority who call themselves educated. I can only hope that any one chancing to read this chapter may be moved to read Andrew D. White's "Warfare of Science with Theology" that he may gain a greater appreciation of the cost of his intellectual heritage.

The constant efforts to explain and interpret Genesis made necessary by new discoveries led to most interesting and amusing results. Ingenious speculation produced the idea that the world was instantly created and yet that the process took six days. Aquinas, the great follower of Aristotle and Augustine, refined this by saying that the essence was instantly created but the shaping took six days.

The Genesis account said that light and darkness appear on the first day although the sun and moon are not created till the fourth. This difficulty is circumvented by the idea that darkness and light are independent entities. As Ambrose said, "We must remember that the light of day is one thing and the light of the sun, moon and stars another — the sun by his rays appearing to add luster to the daylight. For before sunrise the day dawns, but is not in full refulgence, for the sun adds still further to its splendor." [6]

If God was all-powerful and all on earth was designed for man, how was it that injurious animals were created? The answer was found to lie in the result of sin. Before Adam fell there was no sin, no suffering, no antagonism between different species. Bede said: "Thus fierce and poisonous animals were created for terrifying man (be-

[6] WHITE, A. D. o. c., p. 13.

cause God foresaw that he would sin) in order that he might be made aware of the final punishment of hell." [7] Peter Lombard thought "no created things would have been hurtful to man had he not sinned: they became hurtful for the sake of terrifying and punishing vice or of proving and perfecting virtue: they were created harmless and on account of sin became hurtful." [7] Wesley wrote: "None of these attempted to devour or in any wise hurt one another: . . . the spider was as harmless as the fly, and did not lie in wait for blood." [7] Watson, the evangelical reformer of the eighteenth century, thought the serpent had been punished for his sins. "We have no reason at all to believe that the animal had a serpentine form in any mode or degree until its transformation: that he was then degraded to a reptile to go upon his belly imports, on the contrary, an entire loss and alteration of the original form." [7] Augustine thought that many forms of life were superfluous, yet that in some way they completed the design of nature, while Luther held flies to be the images of devils and heretics sent by the devil to bother him while reading.

The appeal to authority produced other results in the field of natural history equally interesting. "Hence such contributions to knowledge as that the basilisk kills serpents by his breath and men by his glance, that the lion when pursued effaces his tracks with the end of his own tail, that the pelican nurses her young with her own blood, that serpents lay aside their venom before drinking, that the salamander quenches fire, that the hyena can talk with shepherds, that certain birds are born of the fruit of a certain tree when it happens to fall into the water, with other masses of science equally valuable." [8] Bartholomew,

[7] WHITE, A. D. o. c., pp. 28, 29.

[8] Ibid., p. 33.

an English Franciscan, in his book "The Properties of Things" which went through ten editions in the fifteenth century and was much used by preachers tells us that "If the crocodile findeth a man by the water's brim he slayeth him, then he weepeth over him and swalloweth him." [9] Bestiaries such as that of William of Normandy were widely employed. "Pious use was made of this science, especially by monkish preachers. The phenix rising from his ashes proves the doctrine of the resurrection; the structure and mischief of monkeys proves the existence of demons; the fact that certain monkeys have no tails proves that Satan has been shorn of his glory; the weasel, which 'constantly changes its place' is a type of the man estranged from the word of God, who findeth no rest." [10] The Dominican Nider in the "Ant Hill" asserted that the Ethiopian ants were as large as dogs and had horns. He thought they typified the heretics, Wyclif and Huss, who "bark and bite against the truth." At the end of the seventeenth century Father Kircher, a Jesuit professor at Rome, was sure that sirens and griffins were among the animals taken into the ark.

The Protestant Reformation, in spite of its protest against the authority of tradition as set forth by the church, instead of introducing the rule of reason but served to strengthen the position of the Bible as the source of knowledge. Luther and Calvin held as firmly to its literal interpretation as did Bossuet or Aquinas. Luther denounced reason as the "arch-whore," "the devil's bride." He called Aristotle "prince of darkness, horrid impostor, public and professed liar, beast and twice execrable." To Copernicus he is equally complimentary:

[9] White, A. D. o. c., p. 34.
[10] Ibid., p. 35.

"This 'upstart astrologer,' this 'fool who wishes to reverse the entire science of astronomy,' for 'sacred scripture tells us that Joshua commanded the sun to stand still and not the earth.'" [11] Well might Erasmus say: "Learning perished where Luther reigned." [12]

The general belief of this later day may be thus stated. Accepting the calculation of the famous Dr. Lightfoot, vice-chancellor of Cambridge University, "man was created by the Trinity on 23d October, 4004 B. C., at nine o'clock in the morning." Moreover, his studies enabled him to declare that "heaven and earth, center and circumference, were created all together, in the same instant, and clouds full of water." [13] Melanchthon put the date of creation at 3963 B. C. while Pope Urban VIII fixed it in the year 5199 B. C. The chronology of Bishop Usher was printed in many editions of the Bible and was quite generally regarded as almost if not quite inspired. So accurate was this general scheme considered that in the nineteenth century Dr. Adam Clark wrote "to preclude the possibility of a mistake, the unerring Spirit of God directed Moses in the selection of his facts and the ascertaining of his dates," while a famous Egyptologist, Wilkinson, modified the dates got from the monuments to fit the accepted date of the flood.[14] Yet two hundred years after Lightfoot, it was known that a great and ancient civilization flourished in Asia at the time he thought creation took place.

All the different kinds of plants and animals had been created in the week set apart for that purpose. The

11 CLODD, EDW. o. c., p. 89.
12 Ibid., p. 87.
13 WHITE, A. D. o. c., p. 9.
14 Ibid., pp. 1–256.

crowning achievement was man, woman being but an afterthought — a side issue, as it were — and many held that man had one less rib than woman. The contrast between man and the other animals was often emphasized. He had been directly formed by the hands of God, while the others had appeared at the call of his voice from the earth or sea. In spite of the threats of the Athanasian creed against all who should "confound the persons" or "divide the substance of the Trinity" there was considerable discussion as to the actual creator. In 1667 Abraham Milius, author of "The Origin of Animals and the Migrations of Peoples," suggested that: "the earth and the waters, and especially the heat of the sun with that slimy and putrid quality which seems to be inherent in the soil, may furnish the origin for fishes, terrestrial animals and birds." [15] He seems to have based this idea on the sentence "Let the earth bring forth the living creature after his kind." In the seventh century St. Isidore had claimed that "bees are generated from decomposed veal, beetles from horseflesh, grasshoppers from mules, scorpions from crabs." [16] This conception of a secondary or indirect creation of many lower forms was widely held.

Early in the eighteenth century Nehemiah Grew of the Royal Society wrote in his "Cosmologia Sacra" that "a crane which is scurvy meat, lays but two eggs but a pheasant and partridge, both excellent meat, lay and hatch fifteen or twenty. . . . Those of value which lay few at a time sit the oftener, as the woodcock and the dove. . . . If nettles sting, it is to secure an excellent medicine for children and cattle. . . . If the bramble hurts man, it makes all the better hedge. . . . If it chances to prick the owner, it tears the thief. . . . Weasels, kites, and other

[15] White, A. D. o. c., p. 46.
[16] Ibid., pp. 1–55.

hurtful animals induce us to watchfulness, thistles and moles to good husbandry; lice oblige us to cleanliness in our bodies; spiders in our houses, and the moth in our clothes." [17] Inasmuch as all was created for man, disease, pestilence, storm and famine were but mysterious exercise of God's will for man's benefit. The elements were used to influence men, as warnings, or as punishments for sin. Tertullian thought the Scripture proved that lightning was identical with hell fire. Then came a gradual growth of a belief in the diabolical origin of storms which might be offset by exorcism. Luther claimed that the sign of the cross with the use of the text "The word was made flesh" would put storms to flight.

Man created in the image of God was perfect from a physical standpoint. Therefore though manslaughter was common and lightly regarded, the dissection of the body was forbidden as impious. What God had wished man to know about the nature of things had been revealed in the Scriptures. Moreover Eve's curiosity had resulted in the fall of Adam and the imposition upon the human race of the curse of work. Inquiry was therefore taboo. Against all inquiry which in any way might reflect on ancient beliefs the church, whether Catholic or Protestant, threw its mighty influence.

In 1650 the Academy for the Study of Animals was founded at Naples but was suppressed by theologians. The Protestants opposed the founding of the Royal Society of London in 1645. Leopold de' Medici was bribed by a Cardinal's hat to neglect the Florentine Academy in which he was interested. Leibnitz was prevented by the priests from founding the Academy of Science at Vienna in 1712. Yet in spite of the efforts to defend "the sacred

[17] WHITE, A. D. o. c., p. 43.

deposit of truth committed to the church," thinking men were driven to new conceptions. Campanella was imprisoned, Copernicus escaped the inquisition by a timely death, Bruno was burned at the stake in 1600, the aged Galileo was forced to recant; yet these men with Kepler, Descartes and Newton destroyed the Ptolemaic system. Against Newton it was urged that he "'took from God that direct action on his works so constantly ascribed to him in Scripture and transferred it to material mechanism' and that he 'substituted gravitation for Providence.'" [18] Notwithstanding the opposition it became clear that the sun and not the earth was the center of our system.

The discovery of the compass, the sextant, the world-wide journeys of the fifteenth and sixteenth centuries furnished a mass of facts which simply refused to be classified on the old basis.

The fossil remains discovered from time to time caused questions. Zenophanes (500 B. C.) as well as Leonardo da Vinci in the fifteenth century had correctly explained them but their suggestions were not accepted. They were due to some "formative quality" or "plastic virtue" of the soil; to "lapidific juice"; to "the influence of heavenly bodies." Perhaps they had been put there by the devil to tempt men to desert their faith or God had established them to mock man's curiosity. The flood was also accepted as explanation, though the fact that these forms did not correspond to any that Noah seemed to have had in the ark was not unnoticed. The great remains of mammoth and mastodon appeared to verify the statement that "there were giants in those days," and they were sometimes permanently exhibited in churches as

[18] WHITE, A. D. o. c., p. 16.

proofs of the Bible. In 1718 a book was published which stated that the height of Adam was 123 feet 9 inches, Eve, 118 feet, 9 inches.

The discovery of strange forms of life in the so-called New World was most embarrassing. St. Paul had declared that the gospel had gone to all lands, hence Augustine had decided that there could be no persons living in the antipodes or other unknown and distant areas. He thought too that God had caused, or permitted, the angels to distribute the species over the earth. In 1667 Milius was puzzled by the fact that many animals common on earth were not found near Mt. Ararat. He could not conceive of their wandering so far. The suggestion that they had been carried by human agency was opposed as early as 1590 by Joseph Acosta in his "Natural and Moral History of the Indies." "It was sufficient, yea, very much, for men driven against their willes by tempest, in so long and unknowne a voyage, to escape with their owne lives, without busying themselves to carrie Woolves and Foxes, and to nourish them at sea." [19] Even assuming that the animals in some mysterious fashion had made their way over earth, how could such species as the sloths of South America make so great a journey from Ararat? If the kangaroo, duck-bill and apteryx could reach Australia, why not the carnivorous wolves and tigers of the Asian mainland? When relatively few species were known the story of Noah's ark did not seem incredible, particularly as Origen had asserted that the cubit was six times longer than had been supposed and Bede had claimed that Noah spent 100 years in its construction, while the animals on board were miraculously fed. Even these

[19] WHITE, A. D. o. c., p. 46.

additions were inadequate when the great multitude of animals was realized.

Difficulty also arose over the question of creation. Aquinas said "Nothing was made by God, after the six days of creation, absolutely new, but it was in some sense included in the work of the six days," and that "even new species, if any appear, have existed before in certain native properties, just as animals are produced from putrefaction." [20] It did not escape observation that there were two not altogether harmonious accounts in Genesis. In the first (Gen. 1:20) it is stated that the waters bring forth fishes, marine animals and birds, while in the second (Gen. 2:19) it is stated that land animals and birds were created from the ground. John Lightfoot tried to reconcile another divergence in the accounts by saying that of the "clean sort of beasts there were seven of every kind created, three couples for breeding and the odd one for Adam's sacrifice on his fall, which God foresaw;" of unclean beasts only one couple.[21] These divergencies caused little trouble — the real question lay in the supposed immutability of species each of which appeared at the time of the creation and remained unchanged. Yet there was as has been indicated a general belief in the spontaneous generation of types more or less insignificant. The decision was in favor of permanency.

Francis Bacon (1561–1626) expressed a doubt as to the fixity of species and asked if the changes that had apparently taken place could be due to the accumulated effects of variations. Bacon was the first of a series of great men, which included Descartes, Leibnitz, Kant, Les-

[20] White, A. D. o. c., p. 55.
[21] Ibid., pp. 1–27.

sing, and Schelling who broke away from the old moorings. By emphasizing variation, they paved the way for the theory of evolution. In the eighteenth century the Benedictine Dom Calmet in his commentary suggests that all the species of one genus had originally been one species. This idea was accepted in part by Linnæus.

Meantime the microscope had come into use. In 1619 Harvey discovered the circulation of the blood though he did not publish the fact until 1628. In 1661 Malpighi actually saw the blood circulating through the capillaries. Vesalius (1514–1564) founded a School of Anatomy at Padua.

The attempt to catalog plants and animals was begun by John Ray in the seventeenth century, but the new era in natural science really opened with Linnæus, the Swedish botanist (1707–1778). He held that the creator had produced a pair of each species of animal and that there had been no increase in the number of species. Each species retained its original characteristics. His studies compelled him to modify this attitude. By 1762 he admits the formation of new types and explains this as the result of the crossing of species. "All the species of one genus constituted at first one species; they were subsequently modified by hybrid generation; that is, by intercrossing with other species." [22] In the last edition of his "Systema Naturæ" (1766) he no longer asserts the fixity of species. He seems to have thought that external conditions could cause degeneration. He based his classification on external characters, while later students depend more upon structure, but this was inevitable, and Linnæus rendered tremendous service by his painstaking observa-

[22] Osborn, H. F. o. c., p. 129.

tions. It is to him that we are indebted for our system of naming the different species.

Conservative as Linnæus was, his ideas did not pass unchallenged. His discovery that an alleged miracle — water turned into blood — was caused by the appearance of vast multitudes of minute insects, led to his denunciation. One bishop said: "'The reddening of water is *not* natural' . . . 'when God allows such a miracle to take place Satan endeavors, and so do his ungodly self-reliant, self-sufficient and worldly tools, to make it signify nothing.'" The discovery is denounced as a "Satanic abyss." [23]

As we have seen, Linnæus had been compelled to change his opinion on the fixity of species. Evidence was gathering from several sides on this point. As observations of the same species in different regions increased and specimens were brought together in collections, certain well defined varieties appeared which were not sharply separated at all points but gradually blended. Species considered distinct were found to have intermediate forms. The confidence of the naturalists in the fixity of species was further weakened by the collection of geological specimens. These not merely indicated that many old forms no longer existed, but showed so clearly that present forms bore such close resemblance to the older that the inference that the latter were descended from the former was unavoidable. A third series of significance was that offered by existing life from the simplest organisms through all the forms to man himself. The suggestion that this showed some connection was inevitable. Further evidence was gained from the life history of the individuals of the

[23] White, A. D. o. c., p. 61.

higher species which were seen to bear striking resemblance to the existing chain of life from the lowest to the highest forms. There came also a revival of interest in the theories of the Greeks which led the philosophers who were by no means ignorant of the significance of the newer scientific discoveries into a new field of speculation. The last factor was the growth of anatomical knowledge which raised many questions as to the assumed perfection of organisms and indicated that many parts were useless survivals. Thus the way was cleared for a new viewpoint.

The first observer to sense the new order was Buffon (1707–1788). In early life he shared, as did Linnæus, the common viewpoint. Later he changed his views markedly. "The pig does not appear to have been formed upon an original, special and perfect plan, since it is a compound of other animals; it has evidently useless parts, or rather parts of which it cannot make any use, toes all the bones of which are perfectly formed, and which, nevertheless, are of no service to it. Nature is far from subjecting herself to final causes in the formation of her creatures." [24]

In middle life he emphasized the rapid variation of species. "One is surprised at the rapidity with which species vary, and the facility with which they lose their primitive characteristics in assuming new forms." [25] Or again: "How many species being perfected or degenerated by the great changes in land and sea, by the favors or disfavors of nature, by food, by the prolonged influences of climate, contrary *or favorable, are no longer what they formerly were.*" [25]

Buffon saw the changes caused by domestication of animals. He noted the high birth rate, the struggle for

[24] Osborn, H. F. o. c., p. 132.
[25] Ibid, p. 133.

existence and the elimination of many individuals. He hints at the common ancestry of ass and horse, of man and ape. He thought the environment modified animals and urged that present changes be studied that older changes might be understood. It is hard to judge Buffon. He is frequently contradictory. He recants his opinions when attacked on theological grounds by the Sorbonne. When expressing himself on some moot points he suggests that inasmuch as the Bible teaches the contrary this view cannot be true. He had less influence than Linnæus largely because he was ahead of his time — but he greatly stimulated research.

Erasmus Darwin (1731–1802) squarely broke away from the idea of special creation. He thought that life originated in water:

> "Hence without parents, by spontaneous birth,
> Rise the first specks of animated earth."

In unmistakable language he pictures the evolution of life from its simplest forms to man himself. "When we revolve in our minds the metamorphosis of animals, as from the tadpole to the frog; secondly, the changes produced by artificial cultivation, as in the breeds of horses, dogs and sheep; thirdly, the changes produced by conditions of climate and of season, as in the sheep of warm climates being covered with hair instead of wool, and the hares and partridges of northern climates becoming white in winter; when, further, we observe the changes of structure produced by habit, as seen especially by men of different occupations; or the changes produced by artificial mutilation and prenatal influences, as in the crossing of species and production of monsters; fourth, when we observe the essential unity of plan in all warm-blooded

animals, we are led to conclude that they have been alike produced from a similar living filament." [26] "Many features in the anatomy of man point to a former quadrupedal position, and indicate that he is not yet fully adapted to the erect position; that, further, man may have arisen from a single family of monkeys, in which, accidentally, the opposing muscle brought the thumb against the tips of the fingers, and that this muscle gradually increased in size by use in successive generations." [27] The theory of natural selection is almost the sole thing in which Erasmus Darwin failed to anticipate his more famous grandson.

Though there is no evidence that Lamarck (1744–1829) knew of the work of Erasmus there is a striking similarity in the ideas of the two. Lamarck became a botanist and was closely associated with Buffon. At the age of forty-nine he changed to zoölogy and was placed in charge of the invertebrates at the Jardins des Plantes in Paris. Up to this time he believed in the fixity of species. In 1802 he suggests the word biology as the title of natural science and sketches an evolution theory which involved the mutability of species and changes, caused not directly by the environment, as Buffon taught, but indirectly through influence upon the nervous system. His "Philosophie Zoologique" (1809) presents his ideas in complete form. He states four laws:

1. Life by its own properties constantly tends to increase the volume of every organism and to enlarge its parts up to the limits which it itself fixes.
2. The production of a new organ in an animal body results from a new need which continues to make

[26] Clodd, E. o. c., p. 112.
[27] Ibid., p. 113.

itself felt and from a new movement which this need starts and continues.

3. The development of the organs and their power of action is constant because of the use of these organs.
4. Everything which has been acquired, or changed in the individual during its life is preserved in the process of reproduction and transmitted to the new individuals which come from those that have undergone the changes.

Lamarck's general conception is simple. The creator endowed matter and life with its qualities. Nature is always creating the lower types. The simplest forms appear first and thenceforth there is a slow, continuous evolution which has taken enormous periods of time. All species shade into each other. The gaps are merely places where we have lost the intermediate forms. The changes are not caused by any scheme or design in nature. They result from the reaction to the environment. "Circumstances influence the forms of animals. But I must not be taken literally, for environment can effect no direct changes whatever upon the organization of animals." Yet on plants he thought direct environmental was effective and he was not entirely consistent with regard to animals. "But great changes in environment bring about changes in the habits of animals. Changes in their wants necessarily bring about parallel changes in their habits. If new wants become constant or very lasting, they form new habits, the new habits involve the use of new parts, or a different use of old parts, which results finally in the production of new organs and the modification of old ones." [28]

[28] Osborn, H. F. o. c., p. 168.

This is the famous "use and disuse" theory and that of the "inheritance of acquired characters" so generally associated with his name. Now it is not to be forgotten that in Lamarck's time the knowledge of the actual world was pitifully small as compared to that we have today. His explanation seemed to meet the known facts. Moreover, opposition grew not out of the details of his scheme, but out of the hostility to any suggestion that might overthrow the belief in a special creation. Thus Cuvier called each of his works "a new folly."

Lamarck thought that the webbed feet of water birds had developed through their efforts to swim. The long neck of the giraffe was due to its stretching to reach the limbs of the trees generation after generation. Deer developed their limbs by the act of fleeing from enemies. Cattle produced horns by butting their heads together. Likewise the vestigial organs have degenerated because of failure to use them. Thus he would have explained the eyes of the mole, the blind salamander or fishes of the caves and the vermiform appendix in man.

Sometimes his explanations became absurd. "The snakes sprang from reptiles with four extremities; but having taken up the habit of moving along the earth and concealing themselves among bushes, their bodies, owing to repeated efforts to elongate themselves and to pass through narrow spaces, have acquired a considerable length out of all proportion to their width. Since long feet would have been very useless, and short feet would have been incapable of moving their bodies, there resulted a cessation of use of these parts, which has finally caused them to totally disappear, although they were originally a part of the plan of organization in these animals." As Osborn remarks, "Such crude illustrations certainly did

not predispose his contemporaries in favor of his theory." [29]

Poor and blind in his later years, Lamarck was ridiculed and opposed by the mighty Cuvier who believed in a series of special creations and attributed the disappearance of extinct form to cataclysms of nature. Lamarck understood the extinction of the lower forms, but thought that man must have destroyed such larger animals as the mammoth. Lamarck made little impression even on France. Not until after the middle of the century did he begin to win recognition as one of the great men of his day.

In the next generation there was comparatively little advance so far as the theory of evolution is concerned. Patrick Matthew in 1831 was the first to clearly state the idea of natural selection. The anonymous work "Vestiges of the Natural History of Creation" (1844), generally attributed to Robert Chambers, by accepting the evolutionary hypothesis aroused much comment. Meantime the botanists were approaching the new standpoint. Meckel and von Baer showed how similar all animals were in the embryonic stages. Rude flint implements of early man were discovered. The stage was being set for the entrance of a group of men destined to have an influence on human thought so great that even today one hardly dares attempt to measure it. The two men most responsible for the movement were Charles Darwin (1809–1882) and Alfred Russel Wallace (1823–1913).

Darwin wrote in his "Naturalist's Voyage Round the World": "In October, 1838, that is, fifteen months after I had begun my systematic inquiry, I happened to read for amusement Malthus on Population, and being well

[29] Osborn, H. F. o. c., p. 170.

prepared to appreciate the struggle for existence which everywhere goes on from long-continued observations of the habits of plants and animals, it at once struck me that under these circumstances favorable variations would tend to be preserved, and unfavorable ones destroyed. The result of this would be the formation of new species." [30] At this time Darwin believed that species were separately created. Four years later he admits that he is "almost convinced that species are not (it is like confessing a murder) immutable." He began to write in 1842 showing his work to the geologist Lyell and to Hooker. Though urged to publish he held back until in 1858 he was astonished to find that his very ideas had been independently worked out by Wallace in a paper sent by him to Darwin with a request that it be forwarded to Lyell if considered worthy. The upshot was that Wallace's paper, together with an abstract of Darwin's, was read under the title "On the Tendency of Species to Form Varieties, and on the Perpetuation of Varieties and Species by Natural Selection" at the meeting of the Linnæan Society, July 1, 1858. An abstract of Darwin's manuscript was published the next year (1859) under the title "The Origin of Species."

A terrific storm broke out in theological circles when the implications of the book were realized. "Cardinal Manning declared Darwinism to be a 'brutal philosophy, to wit, there is no God and the ape is our Adam.' Protestant and Catholic agreed in condemning it as "an attempt to dethrone God' as 'a huge imposture,' as 'tending to produce disbelief of the Bible,' and 'to do away with all idea of God,' as 'turning the Creator out of doors.' . . . 'If,' said Dr. Duffield in the *Princeton*

[30] Clodd, E. o. c., p. 132.

*Review,* 'the development theory of the origin of man shall, in a little while, take the place — as doubtless it will — with other exploded scientific speculations, then they who accept it with its proper logical consequences will, in the life to come, have their portion with those who in this life, 'know not God and obey not the gospel of His son.'" Perhaps the most notable attack came from Samuel Wilberforce, then Bishop of Oxford, in the *Quarterly Review* of July, 1860. "'It is,' said Huxley, in his review of Haeckel's "Evolution of Man," 'a production which should be bound in good stoute calf, or better, asses' skin, by the curious book collector, together with Brougham's attack on the undulatory theory of light when it was first propounded by Young.' The bishop declared 'the principle of natural selection to be absolutely incompatible with the word of God' and as 'contradicting the revealed relations of creation to its Creator.'"[31] . . . "Inconsistent with the fulness of his glory: . . . a dishonoring view of Nature." Another preacher said: "If the Darwinian theory is true, Genesis is a lie, the whole framework of the book of life falls to pieces, and the revelation of God to man, as we Christians know it, is a delusion and a snare." The *Methodist Quarterly Review* (April, 1871) said: "attempting to befog and pettifog the whole question;" "infidelity;" "sophistical and illogical." The *American Church Review* (July and October, 1865 and January, 1866) said: "If this hypothesis be true, then the Bible is an unbearable fiction . . . then have Christians for nearly 2000 years been duped by a monstrous lie. . . . Darwin requires us to disbelieve the authoritative word of the

31 CLODD, E. o. c., pp. 160 and 161. For attacks on Darwin and other scientists, see White, o. c., I, p. 70 ff.

Creator." The *Catholic World* (Vol. xxvi, p. 782) said: "Mr. Darwin is, we have reason to believe, the mouthpiece or chief trumpeter of that infidel clique whose well-known object is to do away with all idea of a God." Cardinal Wiseman with consent of Rome founded an Academia to combat new heresy. Protestants started Victoria Institute from whose platform Reverend Walter Mitchell announced that "Darwinism endeavors to dethrone God." In France Monsignor Ségur said: "These infamous doctrines have for their only support the most abject passions. Their father is pride, their mother impurity, their offspring revolutions. They come from hell and return thither, taking with them the gross creatures who blush not to proclaim and accept them."

In the "Origin of Species" there are only vague references as to the relation of man to the organic world but the logical consequences were quickly realized. Huxley was not slow to show the connection and his volume "Evidence as to Man's Place in Nature" was published in 1863. Darwin did not publish his book "The Descent of Man" until 1871.

Again came an outcry. The *Dublin University Magazine* said that Darwin was "resolved to hunt God out of the world." In 1877 Dr. Constantin James published a volume, "On Darwinism, or the Man-Ape," claiming that Darwin was evidently perpetrating a huge joke. For this he was thanked by Pope Pius IX, who wrote that he "'refutes so well the aberrations of Darwinism, . . . a system which is repugnant at once to history, to the tradition of all peoples, to exact science, to observed facts, and even to Reason herself, would seem to need no refutation, did not the alienation from God, and the leaning toward materialism, due to depravity, eagerly seek a support in

all this tissue of fables. . . . When pride cometh then cometh shame. But the corruption of this age, the machinations of the perverse, the danger of the simple, demand that such fancies, altogether absurd though they are, should — since they borrow the mask of science — be refuted by true science.' " The author was made an officer of the Papal Order of St. Sylvester. The next edition (1882) was entitled "Moses and Darwin: the Man of Genesis compared with the Man-Ape, or Religious Education opposed to Atheistic." The Cardinal Archbishop of Paris said: "We have at last a handbook which we can safely put into the hands of youth." Even Gladstone issued tirades against the new ideas. The Dean of Chichester warned the students of Oxford that "those who refuse to accept the history of the creation of our first parents according to its obvious literal intention, and are for substituting the modern dream of evolution in its place, cause the entire scheme of man's salvation to collapse." Noah Porter of Yale said this would cause a tendency towards agnosticism and pantheism. Rev. Dr. Hodge of Princeton declared that Christians "have a right to protest against the arraying of probabilities against the clear evidence of the Scriptures." When Darwin was buried in Westminster Abbey the Rev. Dr. Laing said it was "a proof that England was no longer a Christian country." Against these rhetorical objectors were arrayed such men as Henry Drummond and Joseph G. Le Conte who labored to show that evolution and religion were not antagonistic. The changed attitude towards the Bible resulting from "higher criticism" compelled a revision of ideas. By the end of the century intelligent religious leaders had accepted the newer philosophy and a few years later it was the basis of the

thought of such popular leaders as Eucken and Bergson.

In the academic world there was at first much opposition. Men holding the new views were dismissed from the American College at Beyrout. Professor Winchell was forced out of Vanderbilt, President Woodrow from the Seminary at Columbia, South Carolina. In England, Whewell, author of the great "History of the Inductive Sciences," refused to allow a copy of the "Origin of Species" to be put in the library of Trinity College, Cambridge. The opposition was however futile, and in the main short lived, though I know of a recent case where a public school director in a middle western state personally destroyed some text books in which evolution was taught.

The scientific world was ready for the change and went over to the new position almost immediately. A few older men, like Agassiz, refused to be convinced. Asa Gray and John Fiske in America, Ernst Haeckel in Germany and Lyell and Huxley in England were early converts. Herbert Spencer, an evolutionist before Darwin, joyfully welcomed the new evidence, and in his "Synthetic Philosophy" was the first to make universal application of the principle.

Darwin's great service really consisted in furnishing the evidence that compelled the acceptance of a theory of evolution. For this the world was waiting and its response was so immediate that in a generation there was hardly a man in any field of science or philosophy who did not profess himself an evolutionist. There are still some few who, admitting evolution of the lower animals, would exempt man; but the theological bias that produces

this result is steadily weakening. Today the intelligent men of the world admit freely that man is a part of the great animal kingdom; and though they recognize his relationship to the chimpanzee, no longer foolishly look upon any existing ape as typical of his progenitor. While the doctrine of evolution lies at the basis of the intellectual life of our day we must be careful not to confuse evolution and progress. Evolution is merely a process leading to better adaptation to given conditions — it may be progressive or retrogressive.

Darwin himself once said that mistaken theories are stimulating but that mistaken observations are sterilizing. Linnæus, Cuvier and Agassiz all opposed the concept of evolution but few men did more to compel its ultimate acceptance. Darwin was primarily interested in determining the causes of survival. He assumed variation and paid little attention to the causes thereof. He observed as Kellogg puts it: " (1) the increase by multiplication in geometrical ratio of the individuals in every species . . . (2) the always apparent slight (to greater) variation in form and function existing among all individuals even though of the same generation or brood; and (3) the transmission with these inevitable slight variations, by the parent to its offspring of a form and physiology essentially like the parental. The inferred (also partly observed) facts are: (1) a lack of room and food for all these new individuals . . . and consequently a competition among those individuals . . . (2) the probable success in this competition of those individuals whose slight differences (variations) are of such a nature as to give them an advantage over their confrères . . . and (3) the fact that these 'saved' individuals will . . . hand

down to the offspring their advantageous condition of structure and physiology." [32]

Darwin thought that the lowest forms of life appeared first. Through reproduction, variation and struggle there resulted a slow, gradual, continuous evolution to the higher forms until man was reached. He saw that man by *artificial selection* decided what types of domestic plants and animals should survive, but he thought that *natural selection* had determined earlier evolution in the main. To this, however, he added *sexual selection* resulting from the choice of mates which in some measure he thought had been a determining factor. Later on he was inclined to believe that perhaps the environment produced some changes directly. Darwin put man also wholly under the law of natural selection, but Wallace felt that his psychical nature could not be accounted for on this basis.

As was hinted at the first of the chapter the fact that Darwin established the principle of evolution by his observations by no means implies that his explanations of the methods or causes will stand. At first so overwhelming was his evidence, so entrancing the new view of life that many of his followers went to far greater lengths in asserting the finality of his ideas than did Darwin himself. Against these claims as well as against some of his own ideas there was bound to come a reaction. This has come and in recent years there have been many death notices of Darwinism written. The reader should not, however, fall into the gross mistake of thinking that opposition to Darwin involves opposition to the concept of evolution. So far as students can see today this idea is here to stay.

[32] Kellogg, V. L. Darwinism To-day, p. 13.

As Kellogg says in the first chapter of "Darwinism To-day": "To too many general readers Darwinism is synonymous with organic evolution or the theory of descent. The word is not to be so used or considered. Darwinism, primarily, is a most ingenious, most plausible, and, according to one's belief, most effective or most inadequate, causo-mechanical explanation of adaptation and species-transforming . . . the fact is that the name Darwinism has been pretty consistently applied by biologists only to those theories practically original with Darwin which offer a mechanical explanation of the accepted fact of descent. Of these Darwinian theories the primary and all important one is that of natural selection. Included with this in Darwinism are the now nearly wholly discredited theories of sexual selection and of the pangenesis of gemmules. . . .[33] The fair truth is that the Darwinian selection theories, considered with regard to their claimed capacity to be an independently sufficient mechanical explanation of descent, stand today seriously discredited in the biological world. On the other hand, it is also fair truth to say that no replacing hypothesis or theory of species-forming has been offered by the opponents of selection which has met with any general or even considerable acceptance by naturalists."[34]

For present purposes we need only say that Darwin was primarily interested in *results:* the later students are dealing largely with *origins.* The newer interest is in heredity rather than evolution and this topic will be treated in the following chapter.

In an earlier section attention was called to the rapid rate of reproduction and the interrelations of the different

[33] Kellogg, V. L. o. c., pp. 2 and 3.

[34] Ibid., p. 5.

forms of life. We must now consider some of the evidence offered to show that there is a selective process in the elimination of individuals or types.

It is readily seen that no selective elimination results from the tornado which kills all in its path save such as chance to be sheltered, to the lightning which strikes by chance, nor to the stream which suddenly going dry destroys all the fishes that chance to be therein. It must be admitted also that many characteristics of animals are negative so far as can be seen. The difference of an inch in the length or a pound in the weight of a cow is meaningless. No one claims that the passenger pigeon perished because it had twelve feathers in its tail or that the mourning dove survived because it had fourteen. If however in the country infested with the tsetse fly cattle appeared, whose skin was so thick that the proboscis of the fly could not penetrate it, the little difference would be very important — the thick-skinned type would live, the thin-skinned be killed. We can find some actual illustrations.

"With silk threads Cesnola tethered forty-five green praying mantises to green herbage, and sixty-five of the brown variety to withered plants. He watched them for seventeen days and all survived unnoticed by birds. But when he put twenty-five green ones among brown herbage all were killed by birds in eleven days, while of forty-five brown ones on green grass, only ten survived at the end of seventeen days. Here we have definite proof of a selective death-rate, definite proof of the selective value of the protective coloration." [35]

"Poulton and Saunders fastened 600 pupæ of the tortoise shell butterfly (*Vanessa urticæ*) to nettles, tree-

[35] Thomson, J. A. Darwinism and Human Life, p. 199.

trunks, fences, walls, and so on. At Oxford there was a mortality of 93 per cent, pointing to an extremely high elimination-rate, and the only pupæ that survived were *on nettles,* where they were least conspicuous. At St. Helens, in the Isle of Wight, the elimination was 92 per cent on fences where the pupæ were conspicuous, as against 57 per cent among nettles where they were inconspicuous." [36]

"Dr. C. B. Davenport of the Carnegie Institution for Experimental Evolution placed 300 chickens in an open field. Eighty per cent were white or black and hence conspicuous; 20 per cent were spotted and hence inconspicuous. In a short time twenty-four were killed by crows but only one of the killed was spotted." [37]

Very different results from those just cited are sometimes obtained. Professor Moore writes: "The large tomato worm . . . occurs in two colors, being generally green, almost exactly matching the tomato leaves and stems on which it lives, and more rarely brown and very conspicuous. These caterpillars may be observed to be not infrequently eaten by robins and cuckoos and pecked to death and partially devoured by chipping sparrows. Last summer 34 of these caterpillars were counted on a row of tomato plants. Of these 32 were of the green and only 2 of the brown phrase. . . . Later in the summer the number of these caterpillars was observed to be gradually diminishing until in early September, when they had attained their full growth, the green ones had been reduced to 18, while both of the brown ones remained. Furthermore, it became apparent that no less than 16 of the green caterpillars were parasitized by an ichneumon fly to whose attacks they eventually succumbed, with the net

[36] THOMSON, J. A. o. c., p. 200.
[37] CHAPIN, F. S. Social Evolution, p. 26.

result that in spite of being protectively colored, out of 32 green caterpillars at the beginning of the season only two — a number just equaling that of the unprotected brown caterpillars — survived to pupate with the latter." [38]

It is possible then to overemphasize the value of protective coloration. Other observers lay stress on mimicry, the close resemblance of one animal to another: a fly to a dangerous wasp, a bug to another disliked by birds because of some very disagreeable odor, a moth hardly to be distinguished at rest from a dried leaf. Though it may not be possible to explain all these phenomena or state their meaning they must have some significance. Moreover, we know that some human beings are more likely to take certain diseases than are other persons and to suffer more from them. If the disease results fatally there may come in time the elimination of the susceptible stock. It would seem then that natural selection is a real factor in life even though its whole rôle is not understood and is perhaps exaggerated.

Biology and paleontology have advanced so rapidly that it is now possible to outline the process of evolution. In the earliest of the stratified rocks, the Azoic, there are no signs of life. This does not necessarily mean that no life existed, but that the early forms of life were simple masses without shells or bones which might be preserved. At the bottom of the animal scale are the one-celled forms called protozoa. Of these the ameba (.01 of an inch in diameter) which is common in vinegar, will serve as an illustration. All we can see is a membrane filled with liquid and inclosing a nucleus. The ameba may slowly move by changing its shape. If it comes in contact with

[38] Moore, E. C. In *Old Penn.* Dec., 1914, p. 361.

a particle of food it wraps itself about it and gradually absorbs it. In the ordinary sense there is no specialization of organs.

Higher than the ameba stand the animals made up of many cells arranged in two layers. The hydra is a cylinder closed at one end where it is fastened to the rocks. At the open end of the cylinder are tentacles which by their motion cause the currents of water to enter the cylinder thus carrying food. The outer cells are protective, the inner layer digests the food.

Next in the scale are the worms in which we find a series of cylinders fastened together. These segments are alike in structure and function. This form characterizes the great mass of invertebrates. Crabs and lobsters as well as beetles and butterflies are built on this plan and are characteristic of the Paleozoic age.

The fishes are the first animals with backbones. The earlier types were covered with heavy coats of mail like the gar pike of our inland lakes. The shark represents perhaps the basic form, a great mass without sharp division of head, body and tail.

The next stage is represented by amphibious creatures which have gills during the earlier stages. Typical of this stage are the salamanders and frogs. These yield place to the reptiles, the lizard, bearing close resemblance to the early type. Snakes are but degenerate lizards. From the reptiles it is but a short step to the birds, the scales being modified to feathers, the fore legs to wings. Here too transitional forms survive like the apteryx of New Zealand, while the penguins and ostriches are wingless in so far as power of flight is concerned. The Mesozoic age is thus one of transition.

Lowest among the mammals are the Ornithorhynchus or

duckbill and its relative the echidna which superficially resembles the hedgehog. Both these lay eggs. The next stage is represented by the marsupials, the so-called Tasmanian wolf, the Australian kangaroo and the American opossum. This brings us to the true placenta-bearing mammals divided into many orders such as the rodents: the rats, mice, squirrels and rabbits; the carnivora: lions, tigers, wolves and seals; and finally to the Primates, at the head of which is man. This development of mammals takes place during the Cenozoic or Tertiary age though clear records of man are not found till the recent or Quaternary. Such is the order of existing life. The same story may be read in the rocks where too are preserved many intermediate forms or "missing links" which prove beyond reasonable doubt the gradual evolution of the various forms of life.

There is no reason to except man from this series. "The supreme place is given to man on account of four and only four characteristics; these are (1) an entirely erect posture, (2) greater brain development, (3) the power of articulate speech, and (4) the power of reason." [39]

Man's nearest relatives are the anthropoid apes of which there are four groups: (1) marmosets, (2) tailed monkeys, (3) baboons and (4) apes (gibbon, orang-outang, chimpanzee and gorilla). The gibbon stands erect using its long arms to keep its balance as it walks. If it goes on all fours the face is parallel with the ground. In the orang-outang the brain development has so changed the position of the head that on all fours it can scarcely bend back its head far enough to look straight ahead. The chimpanzee is still more manlike though its feet are still

[39] CRAMPTON, H. E. Doctrine of Evolution, p. 159.

like hands. In height it is often five feet, or more than some races average. Still closer to man is the gorilla. The brain of the apes is highly developed, averaging between 400 and 500 c.c., though chimpanzees have been found with brains as small as 200 c.c. and gorillas with brains of 610 c.c. To meet human demands it is estimated that the brain cannot be less than 950 c.c. It has been found that the blood of the higher apes is almost identical with human blood. It seems obvious that the differences between men and apes are those of degree and not of kind.

A second line of evidence comes from the development of the individual. All animals, including man, begin as single cells. In the course of development the organism recapitulates in striking fashion the evolution of the race. The microscope shows that the cell is much like the simplest forms of life. At one stage the human embryo has a fish-like heart, brain, muscles, alimentary tract and even gill slits in the sides of the neck. Later on it closely resembles the embryos of the rabbit or cat. Then it bears close resemblance to the embryo of the ape and is covered with a coat of hair which is shed before birth. After birth the child holds its legs just as do the apes, the spinal column is a single curve as is that of the ape, while in the adult man it has a double curve. The human infant for a few weeks has a striking power of supporting itself by hanging on a stick. The hairs of the body have the same slant as do those on the apes. Moreover, the various vestigial organs can only be explained on the assumption that once they meant something to man's ancestors. Thus we have the remnants of a second stomach in the vermiform appendix, the muscles that move the ears, traces of an extra eyelid, muscles and bones that once formed a

tail. The conclusion is irresistible that man is a part of the organic world, the result of a long and slow process of change.

From time immemorial there had been found, in various quarters of earth, pieces of stone, some rough, some chipped to sharp edges, some polished which excited much curiosity, and were often called thunder-stones. In Chaldea they were put in temple walls; in Egypt, strung about the necks of the dead; in India, even today, they are to be found on altars. They were considered weapons used by the gods. "During the Middle Ages many of these well-wrought stones were venerated as weapons, which during the 'war in heaven' had been used in driving forth Satan and his hosts . . . in the twelfth century a Bishop of Rennes asserted the value of thunder-stones as a divinely-appointed means of securing success in battle, safety on the sea, security against thunder, and immunity from unpleasant dreams." [40] At the end of the sixteenth century Mercati tried to show that they were implements of early man but Tollius in 1649 suggested a more acceptable notion when he said that they were "generated in the sky by a fulgurous exhalation conglobed in a cloud by the circumposed humor." [41] In 1715 a pointed weapon of flint was found with the bones of an elephant in London. In 1723 and 1724 Jussien and Labitan in France hit upon the correct explanation and started the study of comparative ethnology. From this time on there was an increasing number both of discoveries and of men who dared defy popular opinion in their interpretations. Geology was denounced as "a black art," "a forbidden province," "an awful evasion of the testimony of revelation," and even Cowper wrote:

[40] WHITE, A. D. o. c., I, p. 266.

[41] Ibid., I, p. 267.

"Some drill and bore
The solid earth and from the strata there
Extract a register, by which we learn
That He who made it, and revealed its date
To Moses, was mistaken in its age!" [42]

With the acceptance of the evolutionary philosophy, the increase in geological knowledge and the rise of anthropology it became clear that the beginnings of life lay further back than had been supposed and that man's own career had been greatly underestimated. Even Sir Walter Raleigh pondering over the civilization of ancient Egypt decided that such "magnificence needed a parent of more antiquity than these other men have supposed." [43]

Again, in spite of the protests of Protestant, Catholic and Greek Church fathers, research continued and one by one the scientists accepted the newer ideas. The most influential convert was the geologist Sir Charles Lyell who, in "The Antiquity of Man" (1863), gave up his old position. Direct evidence was likewise accumulating. The opposition was really destroyed in about 1872 when George Smith showed that the Assyrian and Chaldean legends were the basis of the Genesis accounts.

In 1835 at Cannstadt, Germany, human bones were found under conditions indicating great antiquity. In 1857 at Neanderthal, Germany, were found broken ribs, a shoulder blade and collar bone, upper arm and thigh bones; and the upper part of a skull which not only gave evidence of age, but indicated a type of man lower than existing races. In 1866 at La Naulette, Belgium, was found a piece of a jaw again differing from the typical form of today. In 1886 at Spy, Belgium, remains were

[42] WHITE, A. D. o. c., I, p. 222.
[43] Ibid., I, p. 254.

discovered which had peculiar interest because the Neanderthal type of skull was associated with the La Naulette jaw. By this time Haeckel had described a type of man lower than existing men and given thereto the name "apeman" (*Pithecanthropus*). In 1891 in Java part of a skull, a tooth and thigh bone were found which closely corresponded to Haeckel's description and has since been known as *Pithecanthropus erectus*. This man had an estimated brain capacity of 1,000 c.c. or 400 more than any known ape. In 1907 near Heidelberg, Germany, a most interesting jaw was found, unquestionably human, yet resembling the jaw of an ape, with almost no chin yet with the teeth arranged like those of man. In 1912 in Sussex, England, parts of a skull and jaw bone were found in glacial deposits which again indicated an early type. During the last decade a number of other finds of early man have been made which need not be here described.

It is important to note that the brains of these primitive men are about as large as those of living men. The differences of the face and lower jaw would seem to indicate that we are in some instances dealing with a species different from our own. Our actual knowledge of this great process is still very meager. Very little of the earth's surface has been carefully examined. There is every reason to hope that some day we shall be able to reconstruct the tree of life with comparative accuracy and determine the time factor much more definitely than is possible today. Where man first appeared on earth is very problematical. The earliest forms of life probably appeared near the poles for there the temperature was first reduced to the necessary degree. We know that there was once a continent stretching from Iceland to Java and it is interesting to note that all the discoveries of early

man are in Europe and Java. In America there is no evidence of men who were not closely related to the Indians.

How long this great process has taken we can only roughly estimate. The geologists claim that some 50,000,000 years have passed since the first stratified rocks were deposited and recent students believe that man has been on earth upwards of a million years.

The history sketched in this chapter should teach us at least one lesson. It is not proper for man to set limits beyond which his knowledge may not go nor to attempt to prevent research because of confidence in existing belief. From time to time man has solved intellectual difficulties which had seemed beyond his powers. Recognizing frankly then that many problems are yet unsolved, it would seem wise to hope that increased study and experiment may furnish the answers. It is to be regretted that men like Bergson should appropriate present knowledge, show how it improves our conception of the universe, and then assume that further information can not be had and take recourse in some revamped "vital principle." Is it not better to follow the plan of Columbus when facing unknown seas, in spite of the terrors of the deep and the fears of superstition, and "Sail on, and on, and on"?

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## CHAPTER V

### HEREDITY

Long before man was willing to admit that there might be some organic relationship between himself and other animals, he clearly recognized that he had a body which was maintained and reproduced in similar fashion to theirs. Barring a few illogical exceptions, he believed that each animal reproduced "after its kind," the offspring of lions were lions; of tigers, tigers; of men, men. He had recognized that special traits sometimes appeared generation after generation. So the Romans applied such names as *Capitones, Labiones* to families characterized by peculiar heads and lips, and so Tacitus explained the features of the Germans by saying that they had an unmixed line of descent. The Israelites had even undertaken to control the color of their cattle by exposing them to influences considered potent. There was no clear idea of the nature of growth or of the facts of reproduction; but no one questioned the fact. Today our interest centers in the attempts to understand the machinery and analyze the methods by which these changes are produced.

Our evidence on these points has come from three distinct and yet overlapping methods of research: (1) cytology, or the study of the cell; (2) the breeding of plants and animals; (3) statistical study and comparison.

We have already seen that one-celled plants (bacteria) and animals (protozoa) were discovered shortly after the

invention of the microscope. As early as 1651 William Harvey asserts that all living organisms come from eggs. By 1677 the human spermatozoon is described. In 1665 Robert Hooke, examining a section of cork under the microscope, sees that it is made of "little boxes or cells distinguished from one another." It remained for Wolff (1759) to catch the idea that growth resulted from the multiplication of these small units or cells. In 1831 Robert Brown discovered the nucleus in plant cells. In 1835 Felix Dujardin discovered protoplasm which is today called "the material basis of life" and which always exists in cell form. In 1838 M. Schleiden and Theodore Schwann showed that plant and animal cells were similar in structure. In 1861 Max Schultze said that "a cell is a globule of protoplasm surrounding a nucleus" and in the same year Gegenbauer showed that the eggs of all vertebrates were in reality single cells. This was found to be true of the spermatozoa in 1865.

As a result of these discoveries man learned that all forms of life start as single cells and that growth results from their multiplication through a process of division. But many lowly forms separate when they divide or form mere masses or aggregates with the different cells seemingly identical in structure and function. In the higher forms there is a specialization of parts. Thus we find that in some plants roots, stems, leaves and, in many cases a piece of the root separated from the plant, will grow and produce a complete plant again. A bit of begonia leaf under favorable conditions will do the same while a post of willow stuck in the ground often becomes a tree. Man takes advantage of this fact in the growing of many of his choicest plants for he thus increases them more rapidly than he could from seed, and moreover he

knows that the new ones will be exactly like the older. In many cases the parts of the plant seem to have lost the power of reproducing the whole under ordinary conditions at least.

When we reach the animal world a change in this regard is evident. It may be possible to cut some worms in two and thus produce two worms. But the worm is really a colony of ringed animals little dependent on each other. A somewhat higher form of animal like the lobster will grow a new claw if one is destroyed, but a marked difference from the behavior of the begonia is already to be noted. No part of the lobster's body will produce a new lobster. In other words, the higher we ascend the ladder of life the greater the specialization of function. The cells of the human skin will produce skin, but nothing else; nerve cells produce nerve cells, nothing else. The human body is then composed of millions of cells which have the power of reproducing themselves, but which for some reason are unable to reproduce the entire organism. For this function, however, nature has set apart the germ cells.

In 1883 Van Beneden, taking advantage of aniline dyes which had recently come into use, discovered that the nucleus of the cell had a definite and rather complicated structure. Thanks to the steady improvement of microscopes and of methods of photography a good deal has been learned. In each cell there is a nucleus containing a number of thread-like substances or filaments, which can be stained and thus observed, to which the name "chromosomes" (color-bodies) has been given. These chromosomes are so tangled, are so delicate and perishable, that it has proved very difficult to make accurate count of them. This difficulty has been overcome and we now

know that the number of chromosomes varies with the species, but that it is constant for any given species barring an exception which will be mentioned later. In certain worms the number is as low as four, in some bugs, 10 or 12; in the rat, 16; in the frog or mouse, 24; in man, 48.[1] The nucleus is surrounded by a drop of liquid and the whole is incased in a delicate membrane or cell wall. Attention has already been called to the rapidity of division of many of the one-celled organisms. Under favorable conditions most cells divide at frequent intervals, and the process is most fascinating. The chromosomes contract and then split lengthwise, a half of each moving to opposite sides of the cell and gathering about a nuclear point. Meantime, the cell wall begins to constrict until finally the separation is complete and there are two cells instead of one, enough food having been absorbed in the process so that the daughter cells are approximately as large as the mother cell. It is to be noted that the division of the chromosomes is such that each daughter cell has the same equipment. There is reason to believe that this does not apply to the rest of the contents of the cell, the cytoplasm, where the division may be unequal and hence a basis may be laid for the later differentiation. What causes this division no one knows and concerning this mystery Bateson has well said: "The greatest advance I can conceive in biology would be the discovery of the nature of the instability which leads to the continual division of the cell. When I look at a dividing cell, I feel as an astronomer might do if he beheld the formation of a double star; that an original act of creation is taking place before me. Enigmatical as the phenomenon seems, I am not without

[1] Guyer, M. F. Being Well-Born, pp. 34–41.

hope that, if it were studied for its own sake, dissociated from the complications which obscure it when regarded as a mere incident in development, some hint as to the nature of division could be found." [2]

This description of cell-division, or mitosis, as it is called, holds true for the body cells of the higher animals as well as for the one-celled forms. The mitosis of germ-cells is more complex, and differs somewhat in the two sexes. The common opinion that they come into existence when the animal reaches physical maturity is mistaken. As a matter of fact, they appear at a very early stage in the life of the individual and in some of the lower their history can be traced from the very first divisions of the fertilized egg. Even in mammals they may sometimes be found in the walls of the digestive tract in early embryonic development when they move into the appointed organs as they appear. The significance of this is that they are not produced by any of the specialized tissues of the body but are derived only from the germ plasm.

From the time these germ cells first appear they continually divide in the manner above described and thus increase in number. The sperm cell of the male divides much more rapidly than the ovum of the female and becomes more numerous and much smaller. By the time the chicken is hatched or the child born it is believed this division period is stopped in the female and hence that the body contains all the eggs it will ever have. The germ cells then enter into a period of growth which in the female lasts till the end of the reproductive period. During this time of growth "the chromosomes form a closely wound coil of long chromatin threads, and when these threads uncoil later it is seen that the chromosomes have

2 Bateson. W. Problems in Genetics, p. 41.

united in pairs; this process is known as synapsis, or the conjugation of the chromosomes, and there is evidence that one member of each synaptic pair is derived from the father, and the other from the mother." [3] The line of junction is plainly seen. Finally there come what are known as the "maturation" or "reduction" divisions two in number. In one of these divisions (probably the first) the chromosomes which had previously united separate and the parts, instead of splitting lengthwise as in ordinary mitosis, go into one or the other of the daughter cells, each of which will therefore have but half of the former number of chromosomes. Then follows a division of the common sort. From each of the original cells we now have four cells each containing half of the standard number of chromosomes. The germ cells have now reached the end of their cycle and unless united with one from the other sex are either absorbed or thrown out of the body. In this maturation process a difference between the two sexes becomes apparent. In the male all the four cells thus formed are alike and may function. In the female, however, in the first of the two divisions one cell is of normal size, the other is small and is known as a polar body. At the second division this divides as does the normal ovum, the latter producing again one polar body and one normal ovum. As a result of the two divisions in the female we have one perfect egg and three polar bodies. Nature is apparently producing a cell with the requisite number of chromosomes and at the same time conserving the valuable cytoplasm for the one perfect ovum.

The ovum is spherical in form containing much foodstuff or yolk. The sperm "is among the smallest of cells

[3] Conklin, E. G. Heredity and Environment, p. 131.

and is usually many thousands of times smaller than the egg. In most animals, and in all vertebrates, it is an elongated, thread-like cell with an enlarged head which contains the nucleus, a smaller middle piece, and a very long and slender tail or flagellum, by the lashing of which the spermatozoon swims forward in the jerking fashion characteristic of many monads or flagellated protozoa." [4]

"At the time of fertilization, when the spermatozoon touches the surface of the egg, the egg pushes out a cone of protoplasm at the point of contact, and, lending a helping hand, as it were, draws it into the egg. . . . In a few minutes the head of the sperm has entered. Its tail is often left outside. The head absorbs fluid from the egg and becomes the sperm nucleus, which passes towards the center of the egg. Here it comes to lie by the side of the egg nucleus, and the two fuse. The walls of the combined nuclei dissolve and the chromosomes appear. Half of these are derived from the father through the nucleus of the sperm, and half from the mother through the egg nucleus." [5]

The chromosomes do not immediately fuse, and there is reason to believe that they keep their identity through life. The fertilized cell quickly begins to divide and thus inaugurates the growth of the individual. It is important to note that from each parent comes one-half of the necessary number of chromosomes and that throughout life every cell of the body thus draws one-half of its chromosomes from either sex. It is small wonder that biologists now are inclined to consider the chromosomes as "the carriers of heredity." Just what rôle is played by the cytoplasm of the cell is unknown but neither the nucleus

[4] Conklin, E. G. o. c., p. 15.

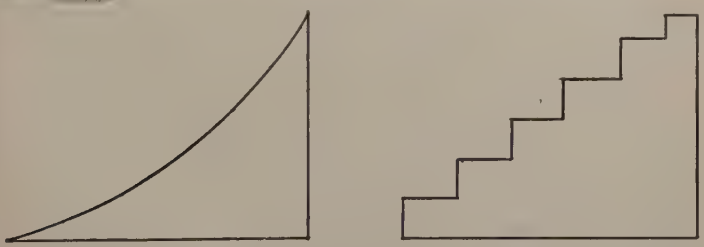
[5] Morgan, T. H. Heredity and Sex, p. 39 ff.

nor the cytoplasm can long function or exist without the other nor can the one create the other. Moreover, the cytoplasm of different animals is as distinct as are the chromosomes.

The fact that the sperm introduces half of the necessary chromosomes indicates that it does more than stimulate the development of the egg. Inasmuch as both sperm and egg originally possess the full number of chromosomes we are puzzled to explain the necessity of sex. Why, for example, may not an egg develop into a complete organism? As a matter of fact such development (parthenogenesis) occurs rarely in nature and has been brought about in the laboratory by the use of certain salts. The eggs of worms, mollusks and even frogs have been stimulated into growth. In some cases the nucleus of the egg has been replaced by the nucleus of the sperm and the cell made to grow. So far as I know none of those has been brought to maturity but whether this is due to some failure to provide for them properly or to some inherent weakness resulting from the lack of fertilization is not known. Among the bees the unfertilized eggs regularly produce males, the fertilized eggs as regularly producing females. Recognizing frankly then that there are many unsolved questions and many apparent contradictions in the present state of knowledge there is a growing opinion that the trail has been found which must ultimately lead to an understanding of the process of reproduction.

In the nineties a Dutch botanist, Hugo de Vries, found some plants of the evening primrose (*Œnothera Lamarckiana*) which had escaped from a neighboring garden and were growing wild. He began to cultivate them and found, to his surprise, that although they had a common ancestry certain new types appeared. One very large

form appeared three times though its ancestors for three generations had been the ordinary *Lamarckiana*. In 1897 the self-fertilized seeds from these produced over 450 plants which, with one exception, were like the giant form. The exception is best described as a dwarf whose seeds reproduced the dwarf form. The commonest new type produced by *Lamarckiana* was one with red veins and brittle stems, which appeared 66 times and also bred true. Here, then, were new species apparently springing into existence in a single generation and breeding true thereafter. The existence of these sudden variations had long been recognized under the name of "sports," but it had been assumed that they quickly reverted to the old type. But the primrose did not revert. Hence De Vries came to the belief that the process of evolution had been a series of sudden changes or mutations rather than the slow unbroken curve pictured by Darwin. The contrast in the two viewpoints may be illustrated by the following diagram.



CONTINUOUS VARIATION DISCONTINUOUS VARIATION

From the standpoint of final result there is no difference. The discovery of the chromosomes, however, makes it possible for us to guess at the cause of sudden variations and to explain their persistence.

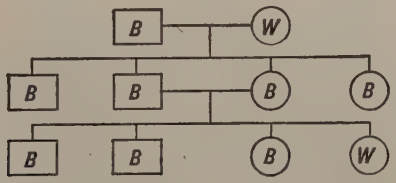
Gregor Mendel (1822–1884), an Austrian monk, in 1866 published in an obscure journal an account of a

long series of experiments he had made with sweet peas. Few students had even heard of this work and it had been ignored by Nägeli, the only prominent botanist to whom it was known. In the light of later discoveries, it suddenly assumed great importance. In the year 1900 the scientific world was surprised to learn that three botanists, De Vries, Correns and Tschermak, working independently and in different countries had come to similar conclusions and had all rediscovered the earlier studies of Mendel.

Mendel found that instead of thinking of the entire plant as a unit he had to consider each plant as made up of various units. He found in the pea seven of these unit characters on which he could depend: (1) the form of the ripe seeds; (2) the color of the substance of the pea; (3) the color of the seed-coat; (4) the form of the ripe pods; (5) the color of the unripe pods; (6) the position of the flowers and (7) the length of the stem. Moreover these characters appeared to go in pairs; the seeds were either smooth or wrinkled, in color they were either yellow or green. If two plants differing with reference to any of these points were crossed all the individuals of the next generation showed one, and only one, of the two characters. To the character that appeared he gave the name "dominant," to the one that disappeared, the name "recessive." Thus Mendel made 58 crosses on ten plants and found that yellow was dominant over green in every instance. He found that the smooth, round seed coat was always dominant over the wrinkled. Here was a puzzle. What had become of the character that did not show? Why was it that all the seeds showed only one character? These hybrid plants are allowed to self-fertilize, and behold 8,023 seeds, of which 6,022 were yellow and 2,001 were green. This it will be noted is a

ratio of about three to one. Five hundred and nineteen of the yellow coated seeds were allowed to grow and again self-fertilize. It was found that 166 produced yellow only, while 353 produced both yellow and those that could produced yellow and green. The hybrids of the round and wrinkled sorts produced 5,474 round and 1,850 wrinkled; those of the tall and short varieties, 787 tall and 277 short; in both cases approximately 3 to 1.

Correns found that if he crossed the white variety of the "four o'clock" with the red variety all the hybrids were pink but that self-fertilized seeds from these pink produced white, pink and red flowers in the ratio of 1 : 2 : 1. At first sight this seems to be different from the results obtained by Mendel but in reality it is the same, the principle being brought out more clearly by the fact that the hybrid is of different color than the pure dominant. Before seeking the explanation let us examine a few other cases.




Color Inheritance in Guinea Pigs

If a black guinea pig of black ancestry be mated with a white of white ancestry all the offspring will be black. If this hybrid generation is interbred the next generation will show three black and one white. This white mated with white never again produces black. The black will be found like the second hybrid generation of Mendel's peas. One-third will produce only black if mated with pure black, while the other two-thirds if interbred will

again produce three black to one white. This may be shown diagrammatically, the squares representing males, the circles females.

About 1836, black and white Spanish chickens were introduced into England. The cross of these two was a finely mottled gray known as the blue Andalusian, much esteemed by fanciers. To their disgust, this "blue" never bred true, about half of the next generation was "blue," the other half black and white. We now see that they were dealing with a hybrid which of necessity produced the original types in a certain percentage of the cases.

We may now briefly illustrate what happens when two sets of characters are crossed, and again we will take Mendel's peas, recalling that round is dominant to wrinkled, yellow to green.

| | Yellow Round | Yellow Wrinkled | Green Round | Green Wrinkled |
|---|---|---|---|---|
| Yellow Round | Yellow Round 1 | Yellow Round 2 | Yellow Round 3 | Yellow Round 4 |
| Yellow Wrinkled | Yellow Round 5 | Yellow Wrinkled 6 | Yellow Round 7 | Yellow Wrinkled 8 |
| Green Round | Yellow Round 9 | Yellow Round 10 | Green Round 11 | Green Round 12 |
| Green Wrinkled | Yellow Round 13 | Yellow Wrinkled 14 | Green Round 15 | Green Wrinkled 16 |

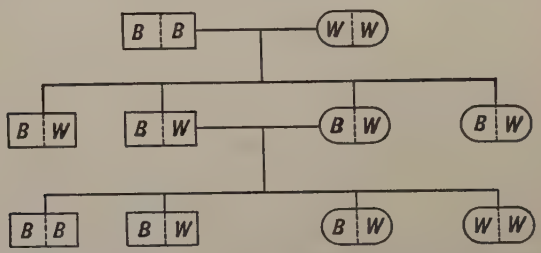
This gives, as will be noted, a ratio of 9 : 3 : 3 : 1, or 9 yellow-round, 3 yellow-wrinkled, 3 green-round and 1 green-wrinkled.

Mendel was keen enough to see that the explanation of

these results lay in the nature of the germ-cells not in any outer conditions. He could not give a complete answer to the questions raised, but he did bring out the fact that the factors causing these phenomena were separately heritable. The rediscovery of his work, in connection with the results of the botanists just named gave a great stimulus to the investigation of heredity and such phenomena are now called "Mendelian" in honor of their first discoverer. Curiously enough, we now know that as early as 1820 John Gross of Devonshire, seeking a new variety of pea, had observed the result of crossing different types but had never followed it up nor discovered any law underlying it.

It so happened that this newer evidence supplemented some of the claims made a decade before by one of the greatest of the successors of Darwin, August Weismann. After 1867 Weismann had undertaken to develop a suggestion made by Virchow in his "Cellular Pathology" in 1858. Inasmuch as every individual starts life as a single cell, and inasmuch as these cells all come from those of earlier generations by a process of division, Weismann became convinced that it was to the germ cells, not to the body as a whole, that we must look for the facts of heredity and variation. He therefore came to think of the germ plasm as something independent of the body in which it was housed and which was passed along generation after generation practically unchanged. He thought that within the germ cells there must be "determiners" of some sort for the various parts of the bodies and saw that if this were true that some of them would have to be discarded or else the union of the male and female cells would double the number. This, as we have seen, was soon found to be true.

If we assume then that there is in the chromosomes a determiner for the different characters and do not forget that each individual gets the chromosomes of his germ cells from two sources and that these are segregated in the first "reduction division" we may hazard an explanation of the above phenomena. Take the case of the guinea pigs. The black pig came of pure black ancestry and we say he was duplex or homozygous in so far as that character was concerned. The white pig had a white ancestry and was likewise duplex. Now when these are mated every ovum of the mother carries a determiner for white and every sperm of the father one for black. Hence all the offspring are simplex or heterozygous in so far as color is concerned, and are all black inasmuch as black is dominant over white. When these hybrids are mated however the chances are that out of four possible combinations black will unite with black once, black with white twice, and white with white once. Such a result is based of course on many matings for one case is not decisive. A cent thrown in the air may come down heads up ten times in succession, but out of a large number of throws heads and tails will be about equal. We may represent what takes place by a simple diagram:




Suggested Explanation of Color Inheritance in Guinea Pigs

Inasmuch as the one at the left in the third generation is duplex black it evidently cannot produce white if mated

with another pure black; while the one at the right is duplex white it cannot produce black again if mated with white. Moreover experience has shown us that white is a recessive and will not show if there is a single determiner for black. The two in the middle are simplex and will therefore produce both white and black if mated.

Suppose now a simplex black be mated with a duplex white, what will be the result? The law of averages will give two simplex black and two duplex white. If duplex black be crossed with simplex black there will be two duplex black and two simplex black.

Some five years ago the writer was given a pair of kittens, brother and sister. Both were short-haired, but the donor claimed that some of their ancestors were long-haired. It is known that short-hair is the dominant, long hair the recessive. For two years only short-haired offspring appeared. Then there was a litter containing one long-haired kitten. This was mated with its father and about half of the kittens since born have been long-haired equal so far as hair length is concerned to Angoras of aristocratic lineage. Inasmuch as these short-haired cats are duplex recessives, they can produce only long-haired kittens if bred with each other.

The difficulty in these cases is that the dominant-recessive cross is of the same color as the pure dominant. In the case of the "four o'clocks" bred by Correns the color is different and the nature of the germ cells or "gametes" is revealed thereby.

Interesting and significant as these facts are it is impossible at the present time to tell how far-reaching the Mendelian phenomena are or what practical use may be made of them. On these points the biologists are divided, some holding that many of the phenomena of inheritance

are of another order, while others believe that as soon as we know the facts we shall be able to interpret on the Mendelian basis. On this subject Darbishire concludes as follows:

"In the opinion of those who accept Mendel's theory as foreshadowing, if not as, in its present state, actually constituting a valid theory of heredity in general, the number of characters concerned every time a fertilization takes place is certainly very large; it is nothing less than the sum total of the characters of the organism in question. According to this generalized Mendelian theory, the organism is made up of a number of characters which are called unit-characters, because they are transmitted as independent units in inheritance. These unit-characters were, in the early days of Mendelian speculation, considered to be associated together in pairs, but . . . the pair is now regarded as consisting in the presence of a particular character as its dominant member, and the absence of this character as the recessive member. But this is a secondary feature of the theory. The essence of it is that the organism is built up of an obviously immense number of separately transmissible unit-characters, the number, limits, and nature of which can be determined by experimental breeding. With regard to the soundness of the theory, all we know at present is that it applies to the relatively small number of characters which have been dealt with in Mendelian studies. This knowledge is sufficient to justify its application to practical problems, if there is reason to believe that the inheritance of the hereditary characters under consideration is of, or approximates the Mendelian type. But this knowledge is not as yet by any means sufficient to warrant even the hope that the

future problems of heredity will be solved by its aid." [6]

A problem arises at once in the attempt to explain what is known as blended inheritance where the hybrids of a cross do not split up into the original characters but preserve the composite character. This is said to be true of the cross between the border Leicester rams and Cheviot ewes in sheep. The cross of the white and the black human races is a mulatto who does not revert so far as known to either parent color. Nillson-Ehle found that a certain brown-chaffed wheat when crossed with a white-chaffed variety yielded a brown-chaffed hybrid which did not in their turn give the Mendelian ratio of 3 to 1 but instead a ratio of about 15 to 1. Careful investigation seems to show that the answer to these difficulties lies in the fact that color is not always fixed by one determiner but that there are several which may be separately inherited and hence the color of hybrids may vary. Thus Nillson-Ehle found two factors for the brown of the wheat and was able to explain the phenomenon on the basis of a dihybrid as illustrated by the chart of the round and wrinkled, green and yellow peas given on page 202. Davenport thinks he can prove that the black color of the pure Negro is due to two double factors. Other observers have reported that seven factors are involved in producing the color of the mouse, and eight for the rabbit. It may be that there is no true blend but that we are dealing with several or many determiners in all cases of blends, which combine in Mendelian fashion.

Of all the questions in the field of heredity that concerning the determination of sex has probably been most dis-

[6] Darbishire, A. D. Breeding and the Mendelian Discovery, pp. 215–216.

cludes certain eye colors; certain hair colors and hair forms, such as straight, wavy, and curly; certain skin colors, such as that of the blond and the brunette; pale, fresh, and colored complexions in the white race; stature, form of head, and nose in certain races; various deformities and defects, such as short fingers, aborted fingers, split-fingers, split-foot, cataract, certain hair deficiencies, stationary night-blindness, certain sex-limited diseases like hemophilia, and color-blindness; and certain kinds of deaf-mutism, insanity, and imbecility. Thus even at this early stage in the study of human heredity, there is good reason to believe that many of our traits Mendelize." [9] Some of these which are of social significance will be discussed in a later chapter. Here we are attempting to state the case only.

In the human eye when the coloring matter exists only on the inner side of the iris the color is blue or gray. If there is also a layer of pigment on the outer side of the iris the color is brown or black. Experience shows that brown is dominant, blue the recessive. Two blue or gray-eyed parents can never have brown-eyed children since there is evidently no factor for brown on either side of the family. If the parents are duplex brown they cannot have blue-eyed children, while if they are simplex brown one-fourth of the children will have blue or gray eyes.

Hair color and hair shape seem also to be Mendelian traits though hair color is due to two pigments, black and red. Dark hair seems dominant to light, and curly hair is dominant to straight.

We must now ask whether these unit characters are fixed or whether they may be modified. De Vries thought

[9] Parker, G. H. Biology and Social Problems, pp. 94–95.

they were as distinct from each other as the chemical elements. Castle and others, by experimenting upon guinea-pigs and hooded rats, have introduced by artificial selection what they regard as marked modifications of unit characters. Castle feels that the unit characters themselves are probably variable. Bateson puts it thus:

"Elements exist in our domesticated breeds (of chickens) which we may feel with confidence have come in since their captivity began. Such elements in fowls are dominant whiteness, extra toe, feathered leg, frizzling, etc., so that even hypothetical extension of the range of origin is only a slight alleviation of the difficulty.

"Somehow or other, therefore, we must recognize that dominant factors do arise. Whether they are created by internal change, or whether, as seems to be not wholly beyond possibility, they obtain entrance from without, there is no evidence to show." [10]

Attention has been called to the fact that the men of Darwin's time put great emphasis on the very slight changes in the organism and thought that the "sports" as they called the marked departures from the normal had little meaning and little chance of survival inasmuch as they would be lost in the average if mated with the ordinary type. It is known today that many of the "mutants" do not revert but breed true and we know, further, that it is possible to combine different units from different plants and perhaps produce a plant superior to the old type. Thus the English wheat has been greatly improved by combining types having grain which possessed the desired qualities with other types whose stems were immune to rust. The beet of Napoleon's time contained only about 3 per cent of sugar. By various crosses we now

[10] BATESON, W. o. c., p. 90.

without exception. In other words the males are homozygous, the females heterozygous.

"Sex-limited inheritance such as this finds its most probable explanation in the existence in the egg of an extra or *plus* element never found in the sperm, this element pairing with the sex-limited character in the reduction division. Thus, in the barred rock, calling barring B, the male of pure race is clearly BB and every sperm is B. But the female clearly contains only one B and cannot be made to contain two. Perhaps a second B is kept out by some structural element, X, the distinctive structural element of the female individual. Then the eggs will be of two sorts: B and X. Since the sperms are all B, the first type of egg when fertilized will contain BB, a homozygous barred individual and a male since it lacks X; the second type will contain BX, a bird heterozygous in barring, and a female, since it contains X." [7]

Diagram of Sex-limited Inheritance, When the Female is a Heterozygote, as in the Barred Fowls X, Female Sex Determiner; B, Barring.

Dorset horned sheep crossed with the hornless Suffolks produce hybrids in which the males all have horns, but none of the females. "A ram will develop horns with only one dose of the horned character which is present in the heterozygous condition of that character: but the ewe needs the two doses which are only present in the homozygous condition of that character."

[7] Castle, W. E. Heredity, pp. 172–174.

It appears then that in many cases a male will show a given character if it has one determiner, that is, is simplex, while the female must be duplex. Why this is true we have no idea. It applies to human beings as well as animals as will be shown.

Color-blindness is much commoner among men than among women. The children of a color-blind man married to a normal woman are themselves normal, but when the girls of this generation marry half of their sons will be color-blind. A color-blind woman is found only when a color-blind man marries a woman whose father was color-blind. If it is true that man is color-blind if he is simplex while the woman only when duplex we should expect all the sons of color-blind women to have the trait and no exception to this is known. Bateson was able to list seventeen cases all of whom were color-blind.

Among other sex-linked traits in man Guyer names: "*hemophilia,* a serious condition in which the blood will not clot properly, thus rendering the affected individual liable to severe or fatal hemorrhage; near-sightedness (*myopia*) in some cases; a degenerative disease of the spinal cord known as multiple sclerosis; progressive atrophy of the optic nerve (*neuritis optica*); Gower's *muscular atrophy;* some forms of *night-blindness;* in some cases *ichthyosis,* a peculiar scaly condition of the skin."[8] All of these characters must be considered as recessives.

How many of the human traits follow the Mendelian principles is not known, but there is reason to think the number is large.

"Already a long list of characteristics, which are inherited in man in accordance with one form or another of the Mendelian principles, is known. This list in-

[8] GUYER, M. F. o. c., pp. 64–65.

cludes certain eye colors; certain hair colors and hair forms, such as straight, wavy, and curly; certain skin colors, such as that of the blond and the brunette; pale, fresh, and colored complexions in the white race; stature, form of head, and nose in certain races; various deformities and defects, such as short fingers, aborted fingers, split-fingers, split-foot, cataract, certain hair deficiencies, stationary night-blindness, certain sex-limited diseases like hemophilia, and color-blindness; and certain kinds of deaf-mutism, insanity, and imbecility. Thus even at this early stage in the study of human heredity, there is good reason to believe that many of our traits Mendelize." [9] Some of these which are of social significance will be discussed in a later chapter. Here we are attempting to state the case only.

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[10] BATESON, W. o. c., p. 90.

have beets grown commercially containing 16 per cent sugar and one of the experiment stations reports a type with 29 per cent sugar. If this last can be made commercially available one can easily imagine how valuable it will become. Other mutants which have proven useful are seen in the famous Concord grape and its later mutants, Worden, Moore's Early, and Pocklington. Nectarines are mutants from peaches; apricots from plums. The Hubbard squash is a mutant. The list of flowers which belong to this category is very large.

Objection has been brought against mutants on the ground that they are all hybrids and that the primroses on which De Vries worked were themselves the crosses of several American varieties. Whatever the truth of the charge the practical value of the combination of different characters remains and moreover the mutants often breed true. As regards any given trait an "extracted" individual may be just as "pure" as one of unmixed ancestry. Indeed this is one of the most important points in the Mendelian theory. Thus Darbishire crossed pure yellow with extracted green of the fifth generation. He got 139,817 seeds, of which 105,045 were yellow and 34,792 (24.88 per cent) were green. These green seeds bred just as true as the pure green.

There is much reason to think then that this conception of mutations is one of the most important in the field of biology. The minor fluctuations about a given form are practically constant and do not lead in any direction but a mutation, which seems to be a new chromosome combination, and may make the beginning of a new line. Furthermore it throws the emphasis upon the nature of the germ cell, not upon the external appearance of the parent. Punnett says, "As our knowledge of heredity

clears and the mists of superstition are dispelled, there grows upon us with an increasing and relentless force the conviction that the creature is not made, but born." [11]

As was shown in the preceding chapter it was long believed that experiences, developments, injuries of one generation somehow or other were reflected in succeeding generations. So thought Darwin as well as Lamarck. Darwin, seeking to explain this, suggested that from the parts of the body affected went little bodies, called "gemmules," which in some fashion were incorporated in the germ cells. In current terms, it was thought that "acquired characters" were inherited. To avoid confusion, be it noted that "acquired characters" are changed in the arrangement of the body cells; that in some fashion these caused changes in the nature of the germ cells so that later generations were affected. The evidence for this seemed so abundant and conclusive, it so closely corresponded to common observation, that men no more thought of questioning it than did those of an earlier time question the revolution of the sun about the earth. Oddly enough, it was this very point which was attacked by Weismann, who came out in flat-footed opposition to the popular idea of the inheritance of acquired characters for he could discover no way in which body cell changes produced any effect upon the germ cells. This bomb was exploded in 1885 and caused as much excitement in biological circles as the doctrine of evolution had produced in the ranks of the theologians.

It seemed easy to overthrow this new heresy and many series of experiments were started in the search for evidence. Among the best known were those of Brown-Séquard who apparently succeeded in producing hereditary

11 PUNNETT, R. C. Mendelism, p. 60.

epilepsy and other defects by a series of mutilations of guinea pigs. At first these were considered conclusive but the same experiment repeated by others failed to produce similar results and hence they are today little regarded. In fact, thirty years have passed, no single clear case has been produced by Weismann's opponents and his main contention is held as established. Again we must note that it is a matter of indifference whether his explanations prove correct or not.

Weismann stated that changes in the body cells had no influence upon the germ cells. Most people little realize what a mass of corroborative evidence lies easily at hand. Every one knows that the sudden changes produced by accident or disease have no such effect. A man is marked by smallpox, but the skin of the children later born is smooth. The broken arm, the amputated leg, the scar of the wound or burn are equally without result. Suppose, however, that a similar condition affected many consecutive generations, might we not then see a result on the offspring? Among various groups of people for countless generations the teeth have been knocked out, the heads changed in shape as among the flat-head Indians, the feet bound as among the Chinese, ears and noses pierced, yet all without result on the race stock. To our knowledge Semetic peoples have practiced circumcision for three thousand years, but the sacred rite is as necessary as ever. The hair and beard grow, though cut for ages. Virgins still have hymens. Child-bearing seems to be more difficult and dangerous for civilized woman than it was for her savage ancestress. If all such changes be grouped under the head of mutilations, it seems fairly certain that they do not affect later generations.

If we consider these changes which we may call improve-

ments or achievements the result is the same. Language is surely one of the most important acquisitions of the race. Yet after all these ages, no child is ever born with any mastery of any dialect. Each generation must learn over again by a long process, both painful and amusing, the symbols of emotion and thought. Furthermore, there is no evidence to show that an English child masters that tongue any more readily than it would the Hottentot if it chanced to be brought up by some family of that tribe. The lack of definite evidence to support the popular conception is quite as evident on the side of improvements as on that of mutilations.

Rather sharply contradictory to the ideas of the scientific world stands a large body of popular belief resting on impressions and careless observations but hallowed by age-long belief. It is generally believed that the body of the child is modified by the activities of his parents. How this is done is not considered. The fact is merely assumed. Thus the child of the blacksmith is believed to have stronger arms than he would have possessed had his father been a school-teacher. The child of the college graduate is thought to learn more easily than would have been possible had the father never trained his mind. On the other hand, the child of the mountaineer is supposed to suffer in comparison with his relative whose parents remained in the cities and went to school. The break-down of the laborer under bad work conditions is held to weaken his children. Hence, these effects are held to be cumulative, increasing the burden of bettering the stock of succeeding generations. In essence, this is but the "use and disuse" theory of Lamarck, which the scientists of today so greatly doubt.

We are forced to the conclusion, then, that there is in

the public mind an inversion of cause and effect. The question of the child's physique or his progress in school turns not upon the occupations of his parents but upon their nature. If he comes from stock that is robust physically the probabilities are that he will show similar characters. If his parents were strong intellectually he will probably resemble them. The reverse is true. If his parents are weaklings, physically or mentally, he will probably be like them. The rôle that opportunity plays will be considered later.

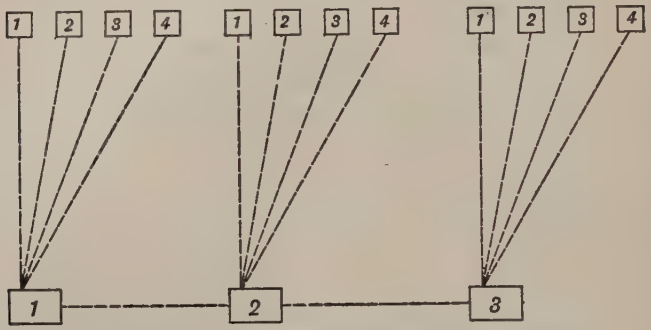
One group of men who have had considerable opportunity for observing the facts of inheritance still insist that the training of parents affects the offspring. Stock breeders point to the increased speed of race horses as conclusive evidence. It is stated that the first reliable record of a mile in three minutes dates from 1818. During the century this record was steadily reduced until now it stands well under two minutes. Redfield claims that he can show that the colts born after the parents have had considerable training have been faster than those born before such training was given. He also claims that this is true of human beings and has offered a reward for evidence that rapidly reproducing families have shown as high capacity as those in which the generations were longer. It is to be noted as a partial answer to these claims that much of the increased speed of the horse must be attributed to lighter sulkies, faster tracks and to improved methods of training. Baseball players of today are superior in technique to those of a generation ago, but there is no reason to suspect any change in natural equipment, nor are the best players today the sons of older players. Athletes' records have been constantly reduced but the record holders of today are not descended

from the great athletes of the last generation. A serious defect in the stock breeder's evidence grows out of the fact that he has discarded the "culls" or unpromising specimens. These must be just as carefully bred as the others before we can be sure of our facts. Until this is done we cannot learn whether the biological attitude must be modified or not.

Explanations sometimes prove too much. It would seem that the theory of the inheritance of acquired characters was of this class. Few people have stopped to inquire how the changes in the body cells produced the alleged changes in the germ cells. Yet, if the theory is true, there must be some mechanism through which this is done. What is it? There is no nerve connection between the germ cells and the rest of the organism. They are not produced by the ovaries or testes within which they live. The unborn child is not connected with the body of the mother by any nerves or by any strand of protoplasm. Only as the blood penetrates the protecting membrane is there opportunity for influencing the body of the child. How, then, are the influences transferred? Darwin, as we have seen, thought that little particles proceeded to the ovaries and were incorporated in the germ cells, but there is not the slightest evidence for this nor can we see how it can take place. One who claims today the transmission of such influence really posits the existence of some machinery which the anatomist has never found.

With few exceptions, present biologists accept Weismann's position. In spite of their prejudices they have been forced to this by the unsatisfactory character of the evidence offered for the alleged cases, by the uniform failure of experiment to produce the expected results and by the absence of any machinery. They have

come to believe that the relation between the generations may be shown by the following diagram:




THE RELATIONS BETWEEN SUCCESSIVE GENERATIONS
(Modified from Wilson.)

In this diagram the succeeding generations are represented by the lower line. The upper groups of figures represent the individual qualities and attainments of the various persons. Each generation is derived, however, not from these personal peculiarities, but from the germ cells which continue with little if any change from one generation to another.

More positive evidence of the truth of this position has been gotten recently. "A female albino guinea-pig, just attaining sexual maturity, was by an operation deprived of her ovaries, and instead of the removed ovaries there were inserted into her body the ovaries of a young black female guinea-pig, not yet sexually matured, aged about three weeks. The grafted animal was now mated with a male albino guinea-pig. From numerous experiments with albino guinea-pigs it may be stated emphatically that normal albinos mated together, without exception, produce only albino young, and the presumption is strong, therefore, that had this female not been operated on she would have

done the same. She produced, however, by the albino male three litters of young which consisted together of six individuals, all black. The first litter of young was produced about six months after the operation, the last one about a year. The transplanted ovarian tissue must have remained in its new environment, therefore, from four to ten months before the eggs attained full growth and were discharged, ample time, it would seem, for the influence of the foreign body upon the inheritance to show itself were such influence possible." [12] *All the young were black.* Other experimenters have secured similar results with rabbits.

Denial of the inheritance of acquired characters must not be understood as a denial of the possibility of the direct modification of the germ cells by environmental influences. Indeed, it is hard for us to conceive how one-celled organisms vary at all unless the outside world in some fashion affects them. It is perfectly possible, then, that the presence of certain chemicals in the body, say large amounts of alcohol or the toxins of disease, may directly produce changes in the germ cells. One of the most important experiments yet made is that of Stockard.

"Guinea-pigs have been treated with alcohol in order to test the influence of such treatment on their offspring. Male and female animals are given alcohol by an inhalation method until they begin to show signs of intoxication, though they are never completely intoxicated. They are treated for about an hour at a time, six days per week. The treatment in some of the cases has now extended over a period of nineteen months. The animals may be said to be in a state of chronic alcoholism.

"Fifty-five matings of the alcoholized animals have

12 CASTLE, W. E. o. c., 35 ff.

been made, forty-two of which have reached full term and are recorded.

"From these forty-two matings, only seven young animals have survived, and five of them are unusually small, though their parents were large, vigorous guinea-pigs. The following combinations were made:

"1. Alcoholic males were mated to normal females. This is the paternal test, and is the really crucial proof of the influence of alcohol on the germ cells, since the defective offspring in this case must be due to the modified spermatozoa, or male germ cells, from which they arise. Twenty-four matings of this type were made, fourteen of which gave no result or very early abortions; five still-born litters were produced, consisting of eight individuals in all, and five living litters containing twelve young. Seven of these twelve died soon after birth, and only five have survived. Four of the survivors are from one litter and the fifth is the only living member of a litter of three.

"2. Normal males were mated with alcoholic females. This is the maternal test. In such cases the alcohol may affect the offspring in two ways — by modifying the germ cells of the mother or acting directly on the developing embryo *in utero*. Only four such matings were tried. One gave no offspring; three living litters were born, one consisting of three premature young that died at birth, while the other two litters consisted each of one young, which have survived. The alcoholic treatment in one of the last cases was only begun after the mother had been pregnant for about three weeks.

"3. Alcoholic males were mated to alcoholic females. This is the most severe test, both parents being alcoholic. Fourteen such matings gave in ten cases no offspring, or very early abortions. Three still-born litters were pro-

duced, consisting in all of six individuals, while only one living young was born. *This single offspring from the fourteen matings died in convulsions on the sixth day after birth.*

"The young that have died in the experiment showed nervous disorders, many having epileptic-like seizures, and all died in convulsion.

*"Nine control matings in the same group of animals have given nine surviving litters,* consisting in all of seventeen individuals, all of which have survived and are large, vigorous animals for their ages. Two young from non-alcoholic parents died, but this mother also died two days later. Her diseased condition doubtless affected the suckling young.

*"Forty-two matings of alcoholic guinea-pigs have given only eighteen young born alive, and of these only seven, five of which are runts, survived for more than a few weeks, while nine control matings have given seventeen young, all of which have survived and are normal, vigorous individuals. These facts convincingly demonstrate the detrimental effects of alcohol on the parental germ cells and the developing offspring."* [13]

A few years ago, Paul Kammerer of Vienna, a believer in the inheritance of acquired characters, made some striking claims of the changes he had been able to produce in the midwife toad and the fire salamander. "The fire salamander, which lives in moist woods has become a favorite of mine. If kept for several years upon yellow clay then his yellow markings become enriched at the expense of the black ground color. If half of the offspring of individuals which have thus become very yellow be

[13] Stockard, C. R. Racial Degeneration in Mammals Treated with Alcohol. Arch. Int. Med., Vol. X, No. 4, p. 369 ff.

raised on yellow soil, the amount of yellow increases and appears in broad regularly distributed longitudinal bands. The other half of the offspring if grown on dark soil becomes less yellow. . . .

"If the parent generation of the fire salamander be raised on black garden soil after some years it becomes largely black, while the young kept upon black soil have a row of small spots on the middle of the back. On the other hand, in young which in contrast with their parents have been raised on yellow soil, these spots fuse into a band.

"If we use yellow paper instead of yellow soil and begin our experiment, as we did before, with scantily spotted individuals, then we obtain enlargement, but no increase in the number of the spots. If we take black paper, then we obtain a reduction in the size of the spots without reduction in intensity of coloration. The young bear the few spots in the middle, while the normal young from the control brood in mixed surroundings at once produce an irregular pattern of markings.

"Heavy moisture produces an increase of the yellow, but only in the number of the spots, none in the size of the spots. Numerous but still small spots may be observed in the progeny put back into the less moist surroundings. Comparative dryness results in loss of brilliancy but not in loss of size in the spots. The same phenomenon may be observed in the progeny which is again kept moist, especially when compared with the control brood which was kept under uniform conditions." [14]

Kammerer is convinced that he has here a case of the inheritance of acquired characters. It is however possi-

[14] KAMMERER, P. Adaptation and Inheritance. *Annual Report of Smithsonian Institute*, 1912, p. 435 ff.

ble, assuming the reliability of the statements, that this animal is in some way so susceptible to environmental influence that slight changes therein produce changes in its development or else that the germ cells are directly affected by the changes in the light and thus modified. Bateson, however, after a long review of Kammerer's work, says:

"I have felt obliged to express serious skepticism as to the validity of nearly all the new evidence for the transmission of acquired characters. At the present time the utmost we are bound to accept is the proof that (1) in some parthenogenetic forms variations, or perhaps we may say malformations, produced in response to special conditions, recur in one or perhaps two generations asexually produced after removal to other conditions. (2) That violent maltreatment may in rare instances so affect the germ cells contained in the parents as to cause the individuals resulting from the fertilization of those cells to exhibit an arrest of development similar to that which their parents underwent.

. . . "As a contribution to genetic physiology these facts are very important and interesting, but I cannot think that any one, on reflection, will feel encouraged by such indications to revive old beliefs in the direct origin of adaptations." [15]

By subjecting the eggs of the common potato bug to unusual conditions Tower has been able to effect changes which seemingly become hereditary. Other experimenters by using X-rays, radium and other substances have considerably modified certain amphibia. All these however are *direct* modifications of the germ cell and are not in the class of body cell changes which subsequently are

[15] BATESON, W. o. c., p. 234.

alleged to be reflected in the nature of the germ cell.

Without assuming a dogmatic position on the subject it seems that we must conclude that the germ cells are ordinarily protected from outside influences. Some of the reluctance to accept this conclusion is doubtless due to the realization that it takes away the basis of much of the old moral teaching. If goodness and badness do not cause physical success or deterioration, what does? Into this discussion we cannot enter now. We must merely state that many things once considered part of the physical heredity are henceforth to be grouped under social heredity; that is, are environmental problems. Each generation transmits to the succeeding the race-stuff of which it is the temporary custodian. This newer knowledge will require some restatement of our ideas. When we know that the single cell divides into two, each sharing the essential elements of the older cell, which shall we consider the daughter, which the mother? Biologically this is our relationship to our parents. They are our elder brothers and sisters, they and we alike, "chips of the old block."

In earlier days it was assumed that the germ cells contained a miniature of the mature organism, like it in all details save size. Now that we know something of its makeup we know that this idea is too naïve. Instead of some "homunculus" in the human germ cell, we must imagine a great number of units of some sort possessing the possibility under favorable conditions of developing into the adult. It taxes our credulity to see how the human spermatozoon whose length is about one-twentieth of a millimeter, combined with the egg which is about one-fifth of a millimeter in diameter — just about visible to the naked eye — not merely may develop but already

contains within itself all the elements of the body, but such seems to be the case. In all probability, we must think of the chromosomes as great chains of units. Whether each of these controls some special part of the body, we have today little idea.

This point calls attention to one common misconception of the newer biological viewpoints. It is often asserted that now all the emphasis is thrown upon heredity and the influence of the environment is ignored or denied. This is far from true. As a matter of fact, the followers of Darwin and Weismann still think that natural selection determines which of the various modifications, variations, mutations, or whatever they may be called, will survive. The change is that they no longer think of the environment as causing the variation. After citing many conflicting illustrations in closely allied species, where in one the part is relatively fixed and in the allied form constantly varies, Bateson says:

"We cannot declare that Natural Selection has no part in the determining of fixity or variability; nevertheless looking at the whole mass of fact which a study of the incidence of variation provides, I incline to the view that the variability of polymorphic forms should be regarded rather as a thing tolerated than as an element contributing directly to their chances of life; and on the other hand that the fixity of the monomorphic forms should be looked upon not so much as a proof that Natural Selection controls them with a greater stringency, but rather as an evidence of a natural and intrinsic stability of chemical constitution." [16]

Up to this point the evidence gotten by the study of the cell by experimental breeding has been considered. There

[16] BATESON, W. o. c., p. 29.

is, however, another method of approach which must be mentioned. In 1846 the Swiss Quetelet in his "Letters on the Theory of Probability" applied statistics to biological problems and offered evidence to show that variation took place in accordance with that law. This method was greatly developed in England by a cousin of Darwin, the late Francis Galton. Its chief advocate today is Karl Pearson to whom we are indebted for the name of the science, biometrics. Inasmuch as this is a method of studying phenomena and involves complicated higher mathematics it would be out of place to discuss it extensively here but we may consider some of the results claimed by its advocates. Inasmuch as it deals with averages based on records of large number of cases, it indicates what will happen *on the average* rather than the results of any particular case. Perhaps the best known of the conclusions of the biometricians is the "law of ancestral inheritance." To use Galton's words: "The two parents between them contribute, *on the average*, one-half of each inherited faculty, each of them contributing one-quarter of it. The four grand-parents contribute between them one-quarter, or each of them one-sixteenth, and so on, the sum of the series $\frac{1}{2}$–$\frac{1}{4}$–$\frac{1}{8}$–$\frac{1}{16}$ . . . being equal to 1, as it should be." In view of the later discoveries that some ancestors seem to make no contributions in given cases, it has been suggested that this law shows us rather "the average amount of resemblance between an individual and particular ancestor." Galton also thought he found that on the average the children of given parents would be more mediocre than the parents themselves, that is, would approach the group average, and this is called "the law of regression." This idea may be shown by the following table:

| *Parents* | *Children* | | |
|---|---|---|---|
| | *Tall* | *Medium* | *Small* |
| Tall | Many | Moderate | Very few |
| Small | Very few | Moderate | Many |
| Medium | Moderate | Many | Very few [17] |

As Galton puts it: "A fundamental distinction may exist between two couples whose personal faculties are naturally alike. If one of the couples consists of two gifted members of a poor stock, and the other of two ordinary members of a gifted stock, the difference between them will betray itself in their offspring. The children of the former will tend to regress, those of the latter will not." The value of some of these observations will be elsewhere considered. Here it is sufficient to note that some able students believe that valuable generalizations may be gotten by statistical methods. It appears that there are some discrepancies between their results and those of the biologists. Just how these are to be reconciled is a matter for the future to decide. For the present we must welcome any methods which give promise of revealing facts whether, in the existing state of knowledge, we can combine them or not.

Our journey has now brought us to the place where one of the greatest stumbling blocks known threatens to upset us, or divert us into bypaths, unless in some way we can remove it.

Do the things we see in men result from "nature or nurture," to use Galton's expression? Are they due to heredity or environment, to blood or to breeding, to use

[17] HERBERT, S. First Principles of Heredity, p. 163.

more common terms? We can avoid much useless controversy if we realize that it is foolish to debate the relative importance of two essentials for there is no standpoint from which they can be so viewed and considered. Both are present and without either the organism is unthinkable. Water and air are alike necessary to the organism. The student then has to discover, if he can, what water or air brings to the body. He must learn what of a man's equipment is due to his inheritance, what to his training. The two are constantly fusing in such fashion that sharp separation even is often extremely difficult. We must not forget moreover that the student in any given field is naturally prone to think, as time goes on, that the factors he is specially studying are more important than the others. Thus he tends to exaggerate unconsciously enough the rôle of his own interests. Furthermore he must often obtain a hearing for his views in spite of the opposition of others, and this is not always easy. It is clear that the popular notions must be modified in many ways. The older conception was that the characters of the body in some way got into the germ cells therein produced. Now we know that this is an inversion of the facts. From the physical side it makes no difference (usually at least) what the ancestors did, but it makes tremendous difference what they were. To what extent this race ancestry is modified generation after generation, either for better or worse, will be considered in the next chapter.

If the word heredity is to be used in our discussions, it must be given a definite meaning. Originally inheritance referred to the property received from the preceding generation. This we may consider its legal use. If this inheritance of property is so arranged that the bulk goes

to the eldest son it may easily happen that great social differences are soon apparent even though the physical ancestry is the same. Because a child is born into a given social environment, among given people with whom he lives, and from whom he gets his language, customs and standards, we say that he inherits them. This is "social heredity." The medical man frequently uses the word "hereditary" when he means congenital, which is purely a chronological term referring to the date at which a given character appears, and in this sense has nothing to do with the origin of the characters. The medical man further offends by speaking of certain diseases as inherited when he means only that they are *transmitted* to the child before birth. The venereal diseases are caused by specific organisms which may enter the body at any time and it is not correct to speak of them as inherited. We must be very careful then if we would avoid ambiguity to give a definite meaning to the term. Conklin has suggested the following: "Heredity may be defined as the appearance in offspring of characters whose differential causes are found in the germ cells." Strictly speaking we do not inherit eyes, feet or arms for the miniatures of these do not exist in the germ cell; but there is something within the cell which causes the development of the parts of the body. In this sense heredity will be used in these pages unless otherwise indicated.

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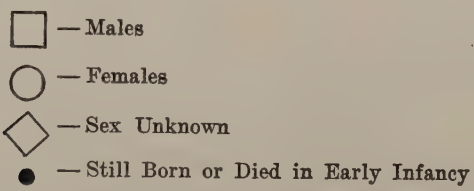
## CHAPTER VI

### HEREDITY AND SOCIETY

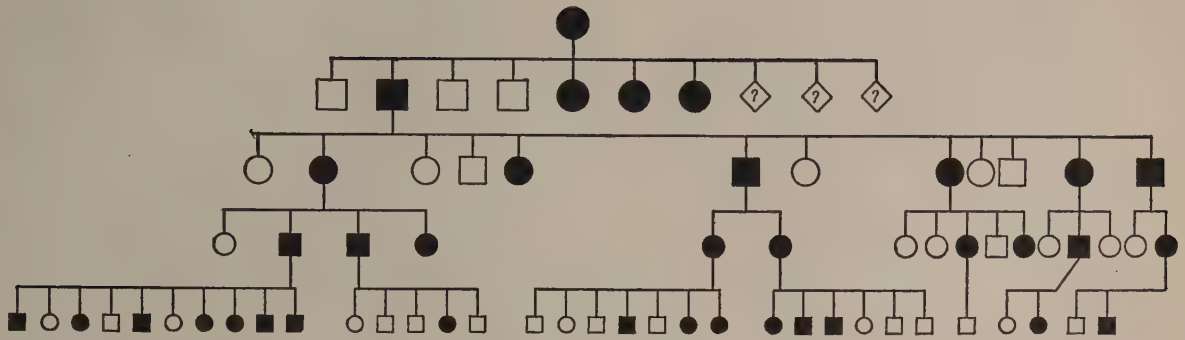
No two human beings are just alike and yet it is possible to divide the human race into great groups which resemble each other in fundamental characters and differ in details. Within a given group the differences between individuals may be as great as those which separate the groups themselves. It becomes possible therefore to subdivide the larger group into many smaller groups which possess this or that physical trait. We call the residents of the United States "Americans" and the word is definite enough for ordinary uses. We all know the component parts of this American people are very unlike, and the words "Whites," "Negroes" and "Indians" bring very different pictures to our minds. In like fashion we may split the white group into many sections. In making such a classification we may proceed to pick out the features in which differences are apparent and merely describe them, or we may consider them in their bearing on the state of society, the possibility of education and civilization. In a word man is always trying to explain social differences on the basis of physical differences, and the attempt is both fascinating and dangerous. In studying human heredity we are not satisfied then to describe what we see, but we try to correlate structure and achievement.

As was mentioned in the last chapter it is now known that many human traits are inherited on a Mendelian

basis. From the standpoint of society, some of these traits are matters of indifference in the main at least. We may know that curly, dark hair, brown eyes and dark skin are dominants, while straight, light hair, blue eyes and pale skin are recessives, and remain unmoved, for we do not see any close connection between these characters and ability. We are familiar with all these characters and have repeatedly seen them in persons of all walks of life and grades of ability. When the average observer learns that there are families characterized by hands quite different from the normal he is at once impressed, and wants to know whether these peculiar hands will not increase the difficulty of handling tools, of doing ordinary work, in other words, of earning a living. Such hands are rather rare and few people probably realize that they exist. Yet they do and they run for generations in a family and are moreover dominant over normal hands. There are three main types, those with an extra finger (polydactylic); those with short and stumpy hands and fingers (brachydactylic); and those more or less webbed between the fingers (syndactylic). Two of these are illustrated in the following diagrams: *



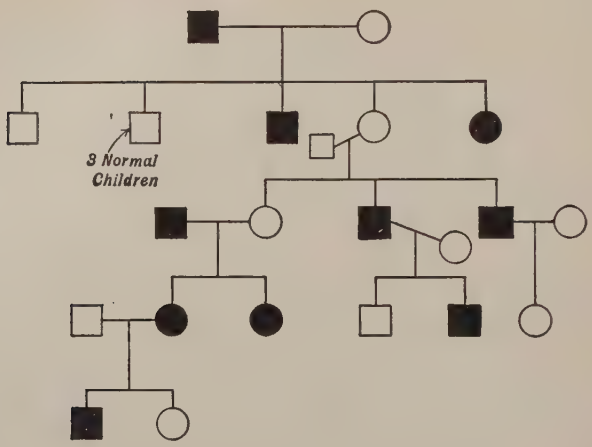

* Explanation of Diagrams: Shaded symbols represent individuals showing the character under discussion.



THE INHERITANCE OF BRACHYDACTYLISM

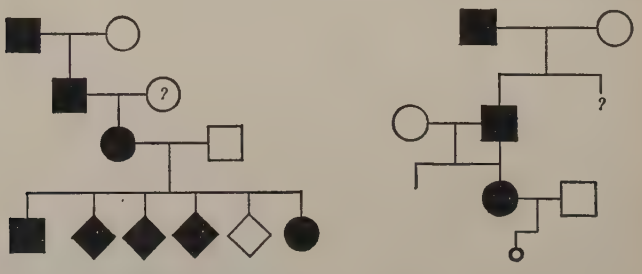
Five generations of a Pennsylvania family in which the bones, particularly of the hands, were shortened. The abnormal members married normal persons so far as known.

[1] FARABEE, W. C. Inheritance of Digital Malformations in Man. *Papers of Peabody Museum,* 1905. Vol. III, No. 3, pp. 69–77.




THE INHERITANCE OF POLYDACTYLISM [2]

Dwarfs are not numerous, and yet are found in all parts of the world. They are ordinarily of low mental caliber, and are unfitted for ordinary employment. There are two general types. The achondroplasic type with large heads and stumpy limbs has a grotesque appearance. This condition is dominant over the normal. The ateliotic are diminutive specimens of ordinary proportions and




ACHONDROPLASIC [3] ATELIOTIC [4]

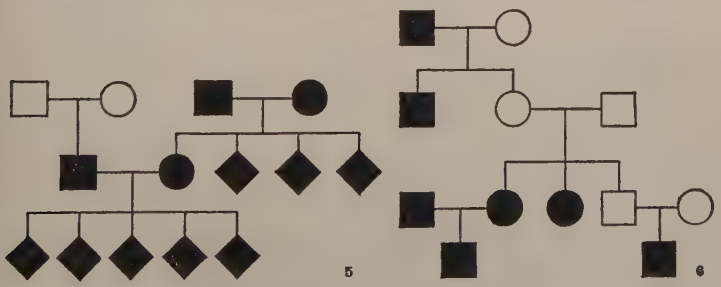
INHERITANCE OF DWARFISM

[2] GUYER, M. F. o. c., p. 110.

[3], [4], PEARSON, K. Treasury Human Inheritance, Figs. 619, 708.

are recessive to the normal. Both conditions are heritable as the diagrams show, though the chart of the ateliotic type is incomplete and does not make clear its recessive character.

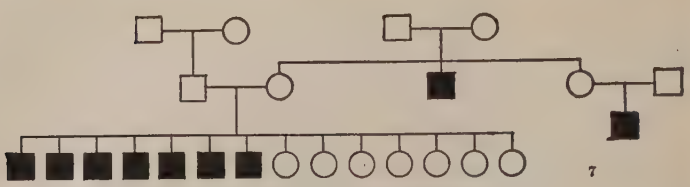
Deafness may be due to some sickness or accident but it is often the result of the inheritance of some peculiar ear formation. No one could consider deaf-mutism as anything but an undesirable affliction. It was known many years ago that the condition was more common among the children of affected families than in the population at large, and many family charts have now been made. These show that the condition may be passed on even though neither parent is affected, i.e., deaf-mutism is a recessive.



INHERITANCE OF DEAF-MUTISM

Hemophilia is one of the sex-linked traits, as before mentioned. The blood does not clot properly and hence even a slight cut may be dangerous or even fatal. In the family here charted the first six sons died as a result of this fact. It is to be noted that the daughters do not show the condition. They will transmit it to their sons but not to the daughters unless they chance to marry men who are also carriers.

[5] PEARSON, K. o. c., Pl. X, Fig. 62.
[6] Ibid., Pl. X, 58.



INHERITANCE OF HEMOPHILIA

These illustrations clearly indicate that a number of physical characters, which must be considered as defects in comparison with the normal, not merely exist in many individuals but are passed along generation after generation. The list is by no means complete. We have all seen albinos who are characterized by an absence of pigment cells so that the skin looks chalky white and the eyes red owing to the blood. This is a recessive condition. On the other hand, the affliction known as hypotrichosis, hairlessness accompanied by loss of teeth, seems to be a dominant. Many others might be mentioned.

Until recently we have assumed that these conditions were peculiar to the individual. Now with the development of biology and accumulation of material from many sources we are coming to believe that direct inheritance has been a larger factor than we have thought. Whenever individuals possessing some peculiar characteristic have settled in an isolated community, geographically or socially sharply separated from other settlements, we are likely to find that these characteristics have been perpetuated and are much more common than in other communities. Thus, in America, Martha's Vineyard was the home of a line of deaf-mutes who have wandered over the country. A colony of "bleeders," originally developing in Sullivan County, Pennsylvania, has formed new

[7] PEARSON, K. o. c., Pl. XXXV, Fig. 392.

settlements in Minnesota, South Dakota and California. Long Island and Fairfield County, Connecticut, were the original seats of much of the Huntington's chorea. As our social surveys are multiplied we find evidence that such minor groupings are far more common than was realized.

Important as we may consider the above mentioned defects we will all admit that mental defects are much more serious from the standpoint of society, particularly if it appears that they are rooted in heredity.

Unfortunately in the present state of knowledge, our information is based almost wholly upon the actions of men, and we know almost nothing of the nature or significance of brain differences. It seems that these things which we consider as attributes of man, memory and the higher forms of thought, depend upon " The human cerebral cortex . . . a superficial layer of the brain with a thickness varying from one and a half to five millimeters and covering an average of 2,352 centimeters " (about one and a half square feet). This cortex is estimated to weigh about 658 grammes. It is composed chiefly of blood vessels, supporting tissues and nerve cells. The blood vessels and supporting tissues are merely mechanical accompaniments of an apparatus, the real functions of which are carried on by the nerve cells. These cells have been carefully studied, their arrangement and distribution made out, and it is estimated that in a single cortex their number is not far from 9,200,000,000. Notwithstanding this prodigious number, these cells and their processes represent only two per cent of the total weight of the cortex; in other words, the cortical nerve cells and their processes in the average man weigh about thirteen grammes. This amount represents a little less than a cubic inch of ma-

terial, or to be more accurate, it will just fill a cube whose edge is 2.35 centimeters. In a man who weighs approximately one hundred and fifty pounds, this amount of substance would represent about one five-thousandth of his total weight, yet this very small proportion of his body serves him as the material basis for a whole life of intelligent activity and is the part of the nervous system chiefly concerned in yielding that almost impalpable product, human personality." [8]

To some extent the different parts of the cortex have control over different reactions and hence differences in ability may rest on different organization of the cortex and may be passed along from one generation to another. There are many unsolved questions here and about all we can be sure of is "no brain, no mind." The new-born child may have all the brain cells it will use, but the connecting links must be developed; or is it better to say, perhaps, that the child must learn to use the connecting links and that this process is what we mean when we speak of "the formation of habits"? This cortex is easily injured and hence the checking of development may come therefrom or *via* the road of heredity. All we need remember here is that the man is not merely an enlarged edition of the child. An adult with the proportions of a child would be a caricature. Our minds as well as our bodies are changed by the experiences of life. We are in part what we are today because of the things we have done.

A further difficulty arises from the belief, held even today, that the body is but the house inhabited by a spirit which once entered into it and will some day depart again. In older days it was even held that some foreign spirit

[8] PARKER, G. H. Biology and Social Problems, pp. 34–35.

might enter in and take possession if the original inhabitant was found absent, or might even dispossess the original owner. Hence the actions of a person might be attributed to possession by "evil spirits," and that chapter of human history dealing with demoniacal possession is both interesting and harrowing.

It has long been seen that actions of men were in some way dependent upon circumstances, upon education and upon health, hence such words as "afflicted" or "gifted" are rather vague. There has come, nevertheless, recognition that the human race grades from those of the lowest mental caliber to those of the highest. Using present terms we may roughly classify men into the following groups:

The Subnormal — The Feeble-minded: Idiot, Imbecile, Moron.

Normal-minded — The Common People.

Supernormal — The Distinguished, the Genius.

Before we attempt to consider these separate classes we must again emphasize the difference between endowment and attainment. Though we cannot put our hands upon the actual physical traits, we know that men differ by nature as well as by nurture. In every-day life it may be impossible to determine the actual contribution of these two factors. This backward child in the schoolroom may have a normal mind which has been poorly trained, or it may be weak through lack of food. It may be suffering from disease, or it may have been crippled by some accident. The distinguished man may be one of only ordinary capacity who has been unusually well trained, or has had the superior opportunities which wealth and social position bring, or who accidentally has done that which has brought renown; or he may be mentally far above the

average. Suspending our judgment on these questions for a time, it is not hard to see that in actual life the unsuccessful are likely to drift into public institutions and become public charges, while the successful rise into public esteem. Nevertheless, capacity is not necessarily shown by position. The generals who shine on the parade ground not infrequently have to be replaced in time of war by others whose talents have not been highly esteemed ere the army wins any notable victories.

Recalling our ignorance of the brain and the necessity of depending upon actions for evidence, it becomes plain why we had to wait for a system of compulsory general education, which involved sending the mass of the children through a given program and the attempt to do this at a given rate, before we could even devise any tests of mental growth and ability. The best that we have were worked out after very careful study of French children by Binet. They are designed to show us the mental age of the child. A boy of ten, let us say, can pass the tests ordinarily done by a child of eight. We say then that his mental age is eight. This tells us nothing of the cause of his retardation. In actual use these tests have proven very satisfactory up to the age of 12 or 13. Many have objected to them on the ground that adults could not pass the tests, but the objection is not well taken. By the same token few college professors could pass the freshman entrance examinations, yet their development is evidently greater than that of freshmen. That these tests in the hands of the inexperienced have often been used to prove feeble-mindedness is unfortunately true, but the trouble lies in the observers, not in the tests. It may be true that when a child is found over two years behind those

of his age he is feeble-minded, but this must be demonstrated.

For about a century we have been gathering into special institutions the feeble-minded. Regardless of actual age they are always children no matter whether they have grown up in the neglect of the back woods or in some almshouse or have been given the best of medical care and educational opportunities. They are different from normal children in their rate of growth, in their death rate, in the coördination of movements and in facial expression. In 2,801 cases in institutions in America the age at death was 20.3 for idiots, 22.9 for imbeciles and 28.5 for morons. They may have remarkable memory, but it is a memory of unconnected and unrelated things, as for instance sentences from a foreign tongue of which they have no understanding. They may have considerable musical ability as did the ex-slave Blind Tom, and yet be unable to master the third reader. They may have the strength of the adult and be able to do all sorts of simple tasks and yet be unfit to care for themselves.

In the earlier years only the lower grades were recognized. These in the lowest group are known as idiots who remain mentally under the age of two; that is, they do not learn to talk, though the ablest among them may use some words. This group is, of course, wholly dependent upon their keepers and often cannot care for themselves in the simplest of bodily functions. They vegetate rather than live.

Above the idiot is the imbecile, who ranges in mental age from three to seven with a corresponding development of powers. They seem physically weaker than normal children of the same age. As their mental powers rise

the coördination of body movements and facial expression approaches the normal. They can be trained to do all the tasks within the grasp of a child of corresponding age, and thus may do much in the way of caring for themselves, always under supervision.

Moron is the term recently applied to the highest group now classified with the feeble-minded. They range from the upper limit of the imbeciles to the mental age of perhaps 12. This highest group are so much like the normal that they have not always been distinguished and would often be unrecognized by the inexperienced. Even institution superintendents ten years ago denied that they differed from the normal. Dr. Barr, the head of the great school at Elwyn, Pennsylvania, claimed, however, that above the feeble-minded was a class which he called the moral imbecile. He thought that they were normal in all things except in their inability to distinguish right from wrong. Our newer tests have shown that we were merely dealing with a feeble-minded group of higher mental age.

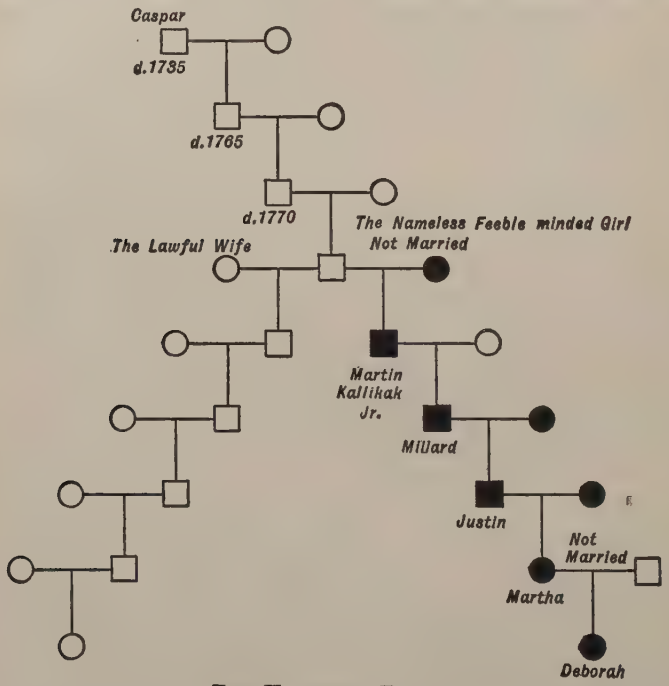
In the earlier days of the study of the defectives it was thought that a sharp line separated them from the normal. Now it is seen that the one shades into the other by imperceptible degrees. Because the lower grades are so easily distinguished from the normal it was thought that their numbers were very limited. Now, as the higher grades are recognized and more accurate surveys are made, it is clear that the number is far larger than had been thought and there has been a growing recognition of the importance of the problem they present. It becomes then a matter of more than passing interest to discover the cause of this condition.

Ordinarily feeble-mindedness is not detected until the

age of infancy is past. Then the child fails to keep up with its fellows and the parents begin to inquire as to the reason. Finally, the mother recalls that at the age of six months the child had a severe fever, or fell from a chair and bumped its head and this fact is then held to be the cause of the trouble. This may be true, but we should not forget that the cause is recalled only after years have intervened and that probably something else also happened which might have been fixed on had not the particular incident been remembered. That is to say, the parents were looking for a cause and were certain to find one. The difficulty is that every child at some time bumps its head hard, or has some sickness, yet only a few fail to develop subsequently. At the other extreme stands the fact that we have no record of two feeble-minded parents producing a normal child. There are such parents with normal children in the family but we cannot always be sure of the percentage of the normal members. In the famous case cited by Goddard the normal children were mulattoes, while both the reputed parents were white. Moreover, where one of the parents is feeble-minded some, occasionally all, of the children are feeble-minded. In other cases, though the parents are both normal, investigation proves that some of their ancestors were feeble-minded. Such phenomena were extremely puzzling until the development of biology and the discovery of unit characters offered possible explanations. Some of the actual family histories may now be considered.

There is no better case than that which formed the beginning of the survey made by the Training School at Vineland, New Jersey, which Goddard details in his valuable book, "The Kallikak Family."

"When Martin, Sr., of the good family, was a boy of fifteen, his father died, leaving him without parental care or oversight. Just before attaining his majority, the young man joined one of the numerous military companies that were formed to protect the country at the




THE KALLIKAK FAMILY

Legitimate line on left — all members normal.
Illegitimate line on right — many members feeble-minded.

beginning of the Revolution. At one of the taverns frequented by the militia he met a feeble-minded girl by whom he became the father of a feeble-minded son. This child was given, by its mother, the name of the father in full, and thus has been handed down to posterity the father's name and the mother's mental capacity. This

illegitimate boy was Martin Kallikak, Jr., the great-great-grandfather of our Deborah, and from him have come four hundred and eighty descendants. One hundred and forty-three of these, we have conclusive proof, were or are feeble-minded, while only forty-six have been found normal. The rest are unknown or doubtful.

"Among these four hundred and eighty descendants, thirty-six have been illegitimate.

"There have been thirty-three sexually immoral persons, mostly prostitutes.

"There have been twenty-four confirmed alcoholics.

"There have been three epileptics.

"Eighty-two died in infancy.

"Three were criminal.

"Eight kept houses of ill fame.

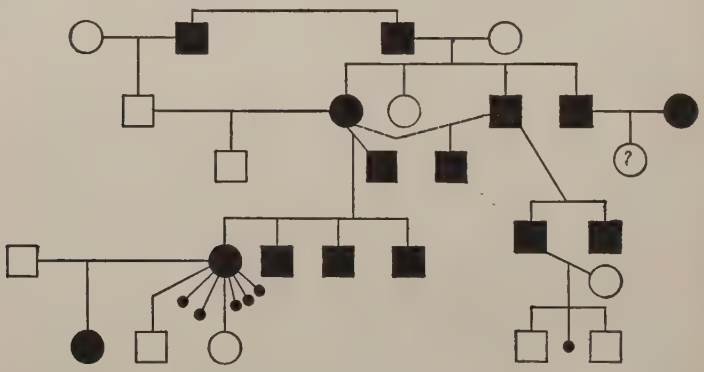
"These people have married into other families, generally of about the same type, so that we now have on record and charted eleven hundred and forty-six individuals.

"Martin, Sr., on leaving the Revolutionary Army, straightened up and married a respectable girl of good family, and through that union has come another line of descendants of radically different character. These now number four hundred and ninety-six in direct descent. All of them are normal people. Three men only have been found among them who were somewhat degenerate, but they were not defective. Two of these were alcoholic, and the other sexually loose.

"All of the legitimate children of Martin, Sr., married into the best families in their state, the descendants of colonial governors, signers of the Declaration of Independence, soldiers and even the founders of a great university. Indeed, in this family and its collateral branches, we

find nothing but good representative citizenship. There are doctors, lawyers, judges, educators, traders, landholders, in short, respectable citizens, men and women prominent in every phase of social life. They have scattered over the United States and are prominent in their communities wherever they have gone." [9]

A study of the following charts will help to make clear the evidence:

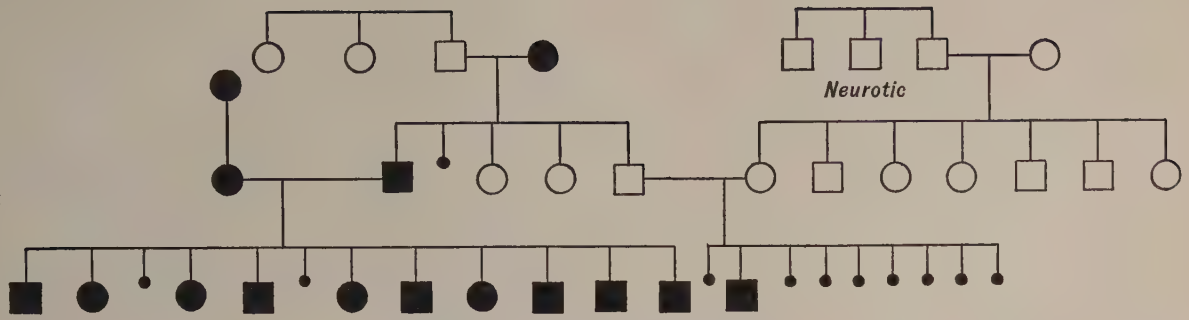



INHERITANCE OF FEEBLE-MINDEDNESS [10]

These three cases chosen practically at random from the hundreds at hand illustrate the various aspects of the problem. In the first we have the intermarriage of related lines which carry the common characteristic, illegitimacy, incest, many deaths of infants and a large percentage of feeble-minded. In the second we see again the results of the marriage of two affected individuals and also the effects of crossing a normal stock with one affected even though the individual person is normal. In the third we have another illustration wherein the father of normal stock has only normal children by his first

[9] GODDARD, H. H. The Kallikak Family, p. 18 ff.

[10] GODDARD, H. H. Feeble-mindedness (redrawn), p. 158.




INHERITANCE OF FEEBLE-MINDEDNESS [11]

[11] GODDARD, H. H. o. c., p. 94.

normal wife, while on remarrying later a feeble-minded woman at least three of his children are known to be afflicted.

To make detailed inquiry into the causes of feeble-mindedness would be inappropriate here, so a general statement must suffice. The illustrations given indicate clearly the possibility of its inheritance. It is probable that within the group we now call feeble-minded are two classes of persons; first, those whose defect has come down

(After Goddard)

CONTRAST IN CHILDREN

from earlier generations; second, those who have been crippled by accident or disease. From an educational or economic viewpoint, these groups are practically alike, biologically they are fundamentally different. The most serious objection to the old explanation in terms of accident and disease lies in the fact already stated, that two affected parents do not have normal children, but their children *should* be normal if the condition resulted from untoward circumstances of life. Moreover, when we increase our surveys of the families of the feeble-minded we almost always discover a lot of cases among the relatives or ancestors hitherto unknown. It is also a striking fact that the percentage apparently coming from perfectly normal families is nearly 50 among the idiots and not more than 25 among the higher imbeciles. Malnutrition, or a failure to develop normally, seems to characterize this lowest group which is so weak that it seldom reaches physical maturity. There is, then, no reproduction from

this group. The higher imbeciles and morons, possessed of the same physical appetites as the normal, but lacking the power of inhibition, are sure to reproduce in or out of wedlock if opportunity offers.

We may then summarize present knowledge with reference to these individuals as follows:

1. Among those now known as feeble-minded are two types of persons: the first, comprising perhaps one-third of the total are victims of circumstances; are usually of low grade, are short lived and present to society a problem of support. The second type, embracing some two-thirds of the total, constitute a sub-species or variation from the normal, usually of higher grade and longer life, and presenting society a problem of reproduction and conduct as well as support.

2. This second type breeds true within itself and there is reason to suspect that it acts on Mendelian lines when crossed again with the normal. Out of 324 matings, Goddard found 708 feeble-minded where the theoretical expectation was 704, and 348 normal when the expectation was 352. He well says: "Such results are difficult to account for on any other basis than that feeble-mindedness is transmitted in accordance with the Mendelian formula . . . normal-mindedness, is, or at least behaves like, a unit character" and "is dominant." [12]

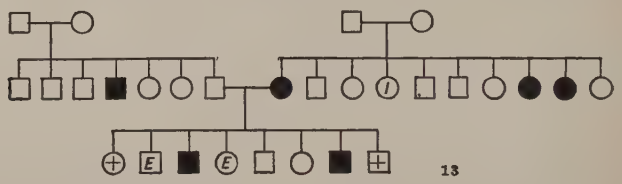
3. We do not know the number of the feeble-minded, but the total in the United States must be upwards of 300,000.

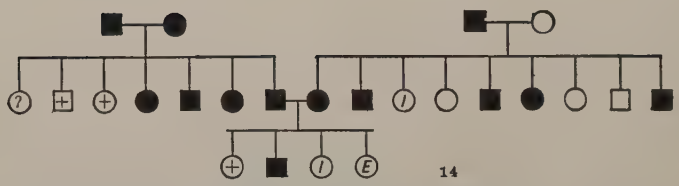
4. Inasmuch as the feeble-minded are differently constituted from the normal they cannot support or conduct themselves as do ordinary people, and will therefore find their way in large numbers into the charitable and penal

[12] GODDARD, H. H. o. c., p. 556.

institutions. Dr. Goddard estimates that perhaps 50 per cent of the inmates of reformatory and penal institutions are feeble-minded. A similar estimate is often made with reference to prostitutes.

Insanity, like feeble-mindedness, is a collective term used to designate many different types of trouble. It seems to be settled that a large part of insanity is due to some disease like syphilis, or to some vice like alcoholism or worry. There is abundant reason to believe, however, that there exists a certain weak or delicate nerve structure which is frequently transmitted generation after generation. Some alienists have stated that they do not know what insanity is, but that given this neurotic type, it is perfectly sure to manifest itself in insanity, epilepsy or alcoholism. In the following charts we have illustrations of the marriage of apparently normal individuals




NEUROTIC INHERITANCE

Affected Individuals Shaded. I Insane; E Epileptic; + Dead, facts unknown.

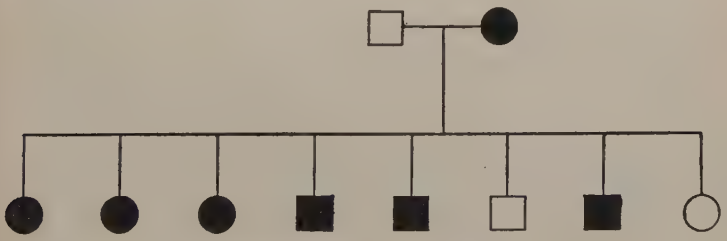
13 DAVENPORT, C. B. Heredity in Relation to Eugenics, p. 78.

14 Ibid., p. 79.

in which this neurotic taint manifests itself in later generations, as well as a case in which it was evident at first.

When we recall that the cost of caring for the insane in recent years amounts to about one-sixth of the entire expenditure of the state of New York, to about one-tenth of that of Pennsylvania and that the number of insane is increasing apparently at the rate of 100 per cent per decade, the importance of determining its cause needs no discussion. In 1910 there were in the United States some 187,791 insane cared for in institutions.

There is some evidence that certain forms of insanity like dementia-precox, and the manic-depressive type are directly inherited and act as recessives to the normal while a rather rare form known as Huntington's chorea is a dominant. A Michigan commission has recently reported that 65.4 per cent of 4,917 insane in the state showed tainted ancestry. Guyer describes a case given in the following diagram:



INHERITANCE OF INSANITY [15]

Epilepsy is a mysterious condition whose causes are unknown. The number of epileptics is perhaps equal to that of the feeble-minded though much less attention has been paid to them. Their relationship to the feeble-minded and the insane is obscure and yet seems to be real. Dr. D. F. Weeks, who is in charge of the Institution

[15] GUYER, M. F. o. c., p. 241.

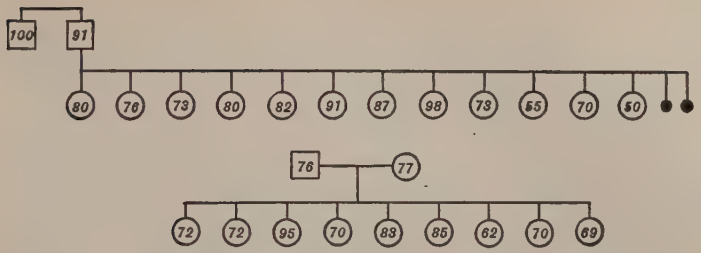
for Epileptics in New Jersey, has written: "That there are five times as many epileptics as feeble-minded in those fraternities coming from matings where neither parent can be classed as normal or called mentally defective, seems to indicate that neurotic and otherwise tainted conditions are more closely related to epilepsy than to feeble-mindedness." He also states that "two epileptic parents produce only defective offspring." [16] Dr. Weeks observed 15 matings where one parent was epileptic, the other feeble-minded. There were living 55 children who were old enough to be classified. Of these 28 were found to be epileptic, 26 feeble-minded and 1 insane.

Further evidence is unnecessary to show us that certain types of mental defects are directly inherited. Whether there has been a real proportionate increase in the classes in recent years may be open to doubt but no one can doubt their presence in the country in very large numbers nor fail to realize the cost of their maintenance. The problem of handling them is further complicated by the fact that these characteristics seem to act usually as recessives, and may be carried to the next generation by men and women who themselves show no sign of the trouble. Evidently, too, under favorable conditions a sub-variety of the human race might easily develop.

Fortunately, however, there is another side to the story. Good traits are inherited as well as bad. By the irony of fate it is often harder to see and appreciate these good features than it is to see the bad, but there are superior as well as inferior types.

Longevity appears to be a family trait judging from the following tables in which the figures indicate age at death:

[16] WEEKS, D. F., in Problems in Eugenics, p. 62 ff.




THE INHERITANCE OF LONGEVITY [17]

These two families who lived in America during the colonial times under conditions by no means exceptionally good so far as is known, whose women were mothers of large families, and yet who averaged nearly twice the length of life of Americans of today, can hardly be explained save on the basis of inherited physique. Moreover, it is possible to find families characterized by short life who have not lived under unusually bad conditions in so far as we can see.

Just as color of hair and eyes, shape of skull or face and stature may be inherited so there is every reason to believe that mental characteristics may descend generation after generation. Here however we encounter great difficulties. Stature and eye color are patent to every observer regardless of the activity of their possessor. Are there different types of mental ability, let us say the mathematical, the philosophical, the executive and the musical, or does ability involve the power of success in many fields? Can we be sure that the actual career of a man is in the field in which his ability really lies?

> "The compass was not invented by an astronomer,
> Nor the microscope by a natural philosopher,
> Nor the printing press by a man of letters,
> Nor gunpowder by a soldier."

[17] THE FOWLERS. Hereditary Descent, pp. 31–34.

At present, the answers to these and similar questions are far from adequate or satisfactory. The clearest case is probably that of the musician, for musical ability seems to rest upon some peculiar attribute of the brain. Some people can never learn to recognize different melodies, let along sing or play, regardless of the amount of training; while others have a keen sense of time, rhythm and harmony even without training. The most famous musical family of modern times started with Weit Bach, a baker of Presburg, Germany, about 1550, who found relaxation in music. His two sons commenced the unbroken line of musicians of the same name that lasted for nearly two centuries. They were all organists or church singers. In no other single family, perhaps, have so many musical geniuses appeared — twenty-nine in all. So, too, Mozart, Beethoven and Amati were members of musical families. Thorwaldsen, Vandyck, Murillo and Titian came from families of artists. With regard to other professions the evidence is conflicting though every one knows of families of lawyers, professors, physicians, as well as business men and cattle dealers. Yet where the son of a distinguished man attains eminence it is as often as not in some different field.

Strange as it seems at first human heredity was not much studied before the last quarter of the nineteenth century, and the would-be student of today finds it extremely difficult to get reliable information with reference to earlier generations, while laboratory experiment is out of the question. Moreover popular verdicts of men and women often rest on such superficial foundations that they have little value to the scientist. We must say, then, there is reason to believe that all sorts of mental ability

may be inherited, but social prestige rests upon so many foundations that real ability must not be inferred therefrom. Thus, there is no reason to doubt the general accuracy of Karl Pearson when he writes, after studying three or four thousand school children in Great Britain:

"I cannot free myself from the conception that underlying every psychical state there is a physical state, and from that conception there follows at once the conclusion that there must be a close association between the succession or recurrence of certain psychical states, which is what we judge mental and moral characteristics by, and an underlying physical conformation be it of brain or liver. . . .

"We are forced, I think literally forced, to the general conclusion that the physical and psychical characters in man are inherited in the same manner, and with the same intensity. The average home environment, the average parental instinct is in itself part of the heritage of the stock and not an extraneous and additional factor emphasizing the resemblance between children of the same home. . . .

"Geniality and probity and ability may be fostered by the home environment and by provision of good schools and well-equipped institutions for research, but that their origin, like health and muscle, is deeper than these things. They are bred and not created. That good stock breeds good stock is the commonplace of every farmer; that the strong man and woman have healthy children is widely recognized too, but we have left the moral and mental faculties as qualities for which we can provide amply by home environment and good education. . . .

"It is the stock itself which makes its home environ-

ment, the education is of small service, unless it be applied to an intelligent race of men." [18]

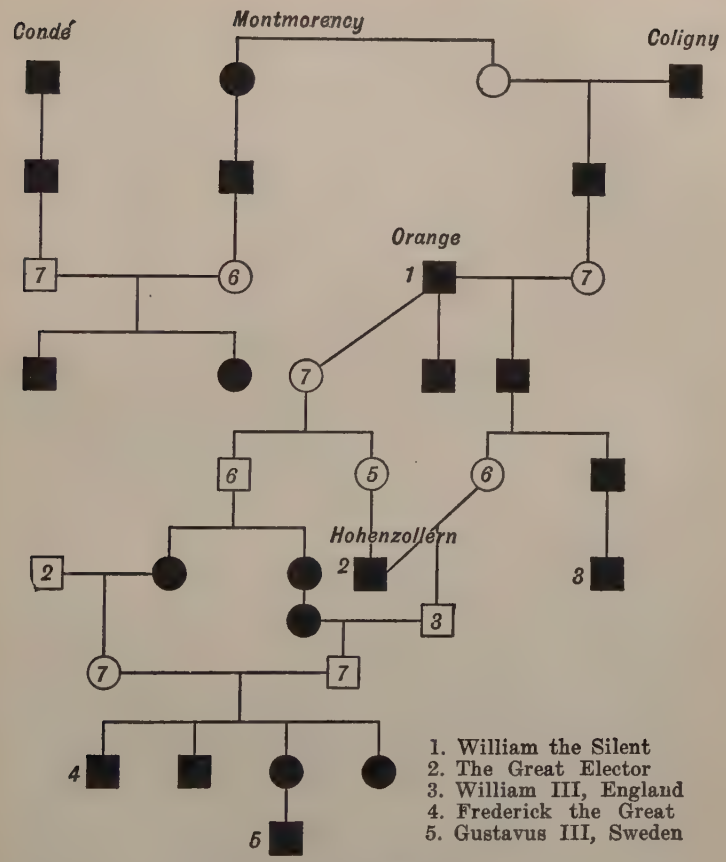
So, too, Dr. F. A. Woods after studying the royal families of Europe writes:

"Many people argue that great geniuses, coming as they frequently do from humble families, Franklin and Lincoln, for instance, discount our belief in mental heredity; when, on the other hand, these men should only strengthen our reliance in this same force. We should consider the thousands, indeed millions, of mediocrities, who have to be born from mediocrities, before one mind of the type of Franklin's is produced. That they rise superior to their circumstances is in itself a proof of the inborn nature of their minds and characters. A man of this sort represents a combination of the best from many ancestors. It would be possible in a great many throws to cast a large number of dice so that they would all fall aces. But here in certain regions of royalty as among the Montmorencys and Hohenzollerns where the dice are loaded, such a result may be expected in a large percentage of throws." [19]

It is interesting to use Dr. Wood's estimate of mental rank and compare a few of the royal families of Europe. In the first the shaded figures represent those individuals put by Dr. Woods in the three highest grades while in the second chart all the black figures are below the sixth grade and only one rises to the seventh.

"If we compare the eight hundred odd persons who form the main body of this study with the world in general, we cannot but be struck with the relatively large numbers of exceptional geniuses who have from time to

[18] Pearson, K. In *Jour. Anthrop. Inst.*, Vol. XXXIII, p. 179 ff.
[19] Woods, F. A. Heredity in Royalty, p. 299.

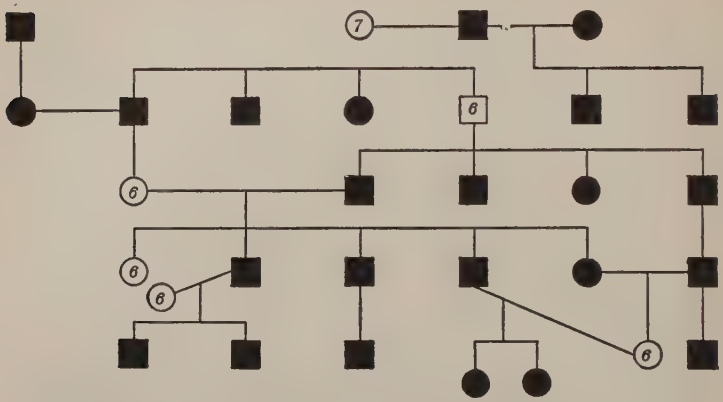



INHERITANCE OF GREAT ABILITY [20]

Shaded figures in 3 highest grades. Numbers in figures indicate grade.

time appeared in their genealogical charts and have taken their places as actual and undisputed leaders in many of the greatest movements in European history. Among the men alone, there are 25 in grades 9 and 10. These are the bearers of names of unquestioned distinction, names of geniuses who stand without superiors in the

[20] WOODS, F. A. o. c., p. 72 ff.




INHERITANCE OF LOW ABILITY. BOURBONS IN SPAIN AFTER 1700 [21]
Shaded figures under Grade 6. Numbers indicate grade.

practical domains of war and government. Where else could we take eight hundred interrelated names at random and find twenty-five world geniuses?

"There is no doubt but that modern royalty, as a whole, has been decidedly superior to the average European in capacity; and we may say without danger of refutation, that the royal breed, considered as a unit, is superior to any other one family, be it that of noble or commoner." To this last claim many will take exception.[22]

Out of each hundred males of the royal families, Dr. Woods puts the following [23] in each of the ten intellectual

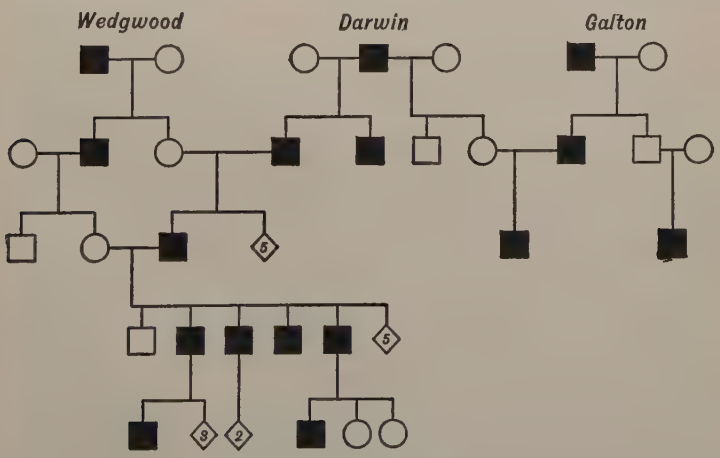
| Class | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Per cent. ... | .17 | 5.3 | 10.4 | 12.4 | 18 | 18 | 17.2 | 10.9 | 4.6 | .17 |
| Cases ..... | 7 | 21 | 41 | 49 | 71 | 70 | 68 | 43 | 18 | 7 |

Total .....395

[21] WOODS, F. A. o. c., p. 154 ff.
[22] Ibid., p. 301.
[23] Ibid., p. 19.

classes, those in class one representing the lowest, those in class ten the highest.

Elsewhere Dr. Woods has shown that eminent persons have a large number of eminent relatives by comparing the 47 elected to the Hall of Fame in New York City with a list of 3,500 formed by adding together the names in two standard biographies. "Now the chances that an ordinary mortal — any man taken at random — will be as closely related (as close as a grandparent or grandson) to any person in this second group (the 3,500 group) is about one in five hundred to perhaps one in a thousand. In contrast to this, fully one-half of those in the Hall of Fame are closely related to some one in the second group, and, if all their distinguished relatives are added up, they average more than one apiece. In other words, the amount of distinguished relationship which the Hall of




INHERITANCE OF ABILITY [24]

Shaded squares represent men of exceptional ability; figures in diamonds represent other children, sex not stated.

[24] WHETHAM, W. C. D. The Family and the Nation, p. 89.

Fame gives is about a thousand times the random expectation." [25]

Admitting, for argument's sake, that all Dr. Wood's claims for royalty is true, and recognizing further the superiority of the Bach family, the ability of the Wedgwood-Galton-Darwin family of England, the Beechers, Adams and Edwards families of America, there is a singular and striking isolation in most of the cases the world calls great. However, we may explain their superiority, it is not hard to see why the world has developed so few families which display and maintain marked characteristics which put them above the rank and file of their contemporaries. This explanation lies in the fact that about the last thing considered by those contemplating marriage is the endowment of the next generation. There is every reason to believe that any given trait might be maintained provided mates were sought among those having similar characters. Every one knows that religious, racial, social, financial considerations and the chance association under favorable surroundings, have outweighed physical factors in the determination of marriage contracts. General health as indicated by beauty and virility has indeed been taken into account, but its influence has not been decisive. Save in sporadic and short-lived experiments, there has been no acceptance of an ideal of good breeding among humans save as regards habits and manners.

Recognizing then the existence of the superman, what is his nature? Does he possess ordinary capacity in most respects plus his extra equipment in one or two directions, or does he secure his gifts by the sacrifice of other qualities? From the days of Ribot and Lombroso on, there

[25] Woods, F. A. In Problems in Eugenics, p. 250.

has been a tendency to regard the genius as an abnormal type approaching the degenerate and therefore to be regarded with suspicion. Even as regards an apparently minor point, stature, Lombroso thought that the geniuses were usually either tall or short men, rather than of average stature.

MEN OF MEDIUM MENTAL ATTAINMENTS

Tall, 16 per cent Medium, 68 per cent Short, 16 per cent

MEN OF GENIUS

Tall, 41 per cent Medium, 22 per cent Short, 37 per cent [26]

"Lebon, on examining the skulls of twenty-six Frenchmen of genius, found that they yielded an average capacity of 1,732 cubic centimeters — a little more than 300 in excess of the average. On the other hand, of the brains of twelve famous Germans studied by Wagner and Buchoff, eight had either a decidedly low or a very high capacity. Doellinger, for instance, had a capacity of only 1,207 cubic centimeters, and Leibig 1,352 cubic centimeters." [27]

Some one has said: "When genius comes in at the door, health flies out of the window." Without attempting to list the physical stigmata by which genius is alleged to be characterized, we may note the claims of the adherents of this degeneracy or insanity conception by quoting from Lydston:

"Æsop, Virgil, Demosthenes, Cicero and Cato were undoubtedly neuropaths. The stammering of Demosthenes is familiar to every schoolboy. Socrates had a familiar genius or demon that dominated the hallucinations of which he was the victim. Pausanius, the Greek

[26] DORLAND, W. A. N. Age of Mental Virility, p. 201.
[27] Ibid., p. 204.

traveler and geographer, murdered a slave and was ever after pursued and tormented by the spirit of the murdered youth. The immortal Lucretius suffered from intermittent mania, and suicided at forty-four. Peter the Great had epilepsy; one of his sons had convulsions, and the other hallucinations. Linnè was a precocious genius who had a hydrocephalic cranium. Raphael was often tempted to suicide. . . . Paschal suffered from nervous troubles and paralysis all his life, and died in convulsions. . . . Molière was a sufferer from convulsions. The slightest excitement or opposition would suffice to precipitate an attack. Mozart was a musical prodigy. He composed at four years of age. He was affected by fainting fits, and was warned of impending death by a vision. He died of brain disease at thirty-six. Cuvier, Victor Hugo, Chopin, Bruno, Comte, Madame de Staël, Swift, Johnson, Cowper, Southey, Shelley, Byron, Carlyle, Goldsmith, Lamb, Poe, Keats, Coleridge, De Quincey, Chatterton, George Eliot, George Sand, Alfred de Musset, Newton, Chateaubriand, De Balzac, Chatham, Burns, Dickens — all of these beacon-lights of the history of genius showed indubitable evidences of degeneracy. In some of them the evidences of mental alienation were very striking. Hugo was dominated by the egotistic idea of becoming the greatest man of all time. Giordano Bruno thought he contained the essence of God. De Staël was an opium-eater; she feared the sensation of cold after death, and stipulated in her will that she be buried in furs. Swift was of insane stock; he was naturally cruel and given to violent and aggressive outbursts of temper. He suffered from serious impairment of vision and audition, with muscular twitching and facial paralysis. Shelley was called "mad," he had hallucinations and was the victim

of the opium habit. Charles Lamb was confined in an asylum. A sister of his suffered a similar fate, and is said to have murdered her mother during one of her maniacal attacks. Johnson had convulsions and cramps, hallucinations and at one time aphasia. Southey had a neurotic ancestry, and died an imbecile. Cowper was afflicted by melancholia. He attempted suicide on numerous occasions. His melancholia finally assumed the religious type, and he was confined in an asylum for a year and a half. Byron's ancestry was bad, and his brain was as clubbed as his foot. Thomas Chatterton was a weakling, called back to the bosom of nature before his time, through the agency of self-murder. Poe, the man who stands out in boldest relief in American literature, was a dipsomaniac and not unlikely a lunatic. . . .

"The list of geniuses who have been shown to be indubitably insane is a long one. Vico died demented; Haller was religiously insane; Ampere believed himself possessed by the devil; Nathaniel Lee, the dramatist, did his best work while insane; Thomas Lloyd, Schumann, Gérard de Nerval, Baudelaire, Comte, Torquate Tasso, Dean Swift, Rousseau and Schopenhauer are among the great men whose histories would adorn the pages of an alienist's records quite as well as they have the history of genius." [28]

One may admit that this account is exaggerated, not to mention the vastly greater claims made by Max Nordau, and yet be forced to recognize that where there is so much smoke there must be some fire. While the contributions of genius may be worth all they cost, it is probably fortunate that society at large is made up of ordinary men and women.

[28] Lydston, G. F. Diseases of Society and Degeneracy, p. 460 ff.

The steady convergence during the last quarter century of several lines of research has at last produced the conviction in the minds of thinking and well-informed men and women that society must pay attention to the question of human heredity for the sake of the future of the race.

The older students had held to the idea that all men were of relatively equal responsibility for their acts, since all possessed free-will. Lombroso in his great work "The Delinquent," published in 1876, challenged this attitude. He and his followers known as the "Positive School of Criminologists" insisted that the criminals, aside from those whose offenses were accidental, were marked off from ordinary men by physical stigmata which indicated degeneration or a reversion to a more primitive type of humanity. Though their extreme claims do not appear warranted, there is a much more general acceptance of them in essence than there was at first and the attitude of the public towards the criminal is being steadily modified.

In America the investigation of the degenerate families of the Jukes in New York in the seventies, the Ishmaelites of Indiana in the nineties, the Kallikaks of New Jersey and the Sixties of Ohio in this decade has revealed the existence of a great army of more or less degenerate individuals reproducing generation after generation and causing an enormous expense by their crimes and their inability to care for themselves.

Meantime Galton and his followers have been studying the superior types of humanity and urging concerted efforts to improve the race stock. With this has come the emphasis which stock-breeding, and the production of desirable new varieties of plants and animals, together with the newer biology and the increased knowledge of heredity, has given to the desire to grapple with

human problems. The result is the movement known as "eugenics."

This movement has two very different sides, negative and positive. Negative eugenics is the attempt to stop the reproduction of the unfit. Naturally there is much division of opinion as to the meaning of this term, but no one doubts the unfitness of the feeble-minded, of the lower grades at least. It is suggested therefore that their reproduction be prevented. This may be done by the prohibition of marriage provided such prohibition be enforced. Inasmuch as they will procreate outside the family relationship, this in itself is not sufficient. It must be supplemented therefore either by a policy of segregation in institutions, particularly of women during the child-bearing years, for all who cannot be adequately protected at home, or by sterilization through a surgical operation. Such an operation is much more difficult in the case of the women than in the men, but the chief danger is from the former. To such a program objection is brought on two grounds. Certain religious institutions seem to feel that it is sacrilegious and that there is a divine right of procreation regardless of the type of children to be expected or the ability of the parents to care for them. The second argument is based on the fear that the power which this policy would lodge in some committee might be abused, that there is no agreement as to where the line should be drawn and that sexual immorality would be encouraged by the knowledge that children could not result. One who knows the feeble-minded can only be amused at the last argument, for immorality on their part is solely a question of opportunity. That the upper limits of those to be so treated is hazy is admitted and only as evidence accumulated

from experience could other groups be included. Though these proposals are, as a matter of fact, part of the law in some twelve states, the movement for sterilization will not make much headway, probably, until the terrific cost of segregating the unfit is appreciated.

It is clear that many of the insane and those suffering from transmissible contagious disease, particularly those having venereal disease, should not marry and the movement to prohibit such marriages is growing. Such prohibition may be found in the laws of some states. It is to be expected that sooner or later a physical certificate will be required of all who contemplate marriage and in so far as men are concerned this is now the law in Wisconsin. It is foolish however to limit its application to men. If some such laws were enforced, the burden of the unfit might be greatly reduced in a couple of generations and the question of the extension to new classes would then be much simpler. It is too much to hope that such prohibitions will be extended to individuals of afflicted stock, themselves normal, much as the biologist may recognize the danger from them. The sterilization of criminals guilty of sexual offenses has often been urged, and actually carried out in a few instances, but such laws as exist are usually disregarded.

Negative eugenics is probably more generally practiced by individuals than is realized. There are many who do not marry because they know they come from neurotic stock and fear lest they have defective children. There are others who are careful to pick wife or husband from a family which has not shown in its history the same type of weakness. We may be able to accomplish a good deal if we can get intelligent people to consider this matter. Why should we not, for illustration, train the

girl of a family which has suffered greatly from tuberculosis, that she must never consider as a possible husband a man of similar ancestry? As a matter of fact we all know of such cases. I have used this illustration deliberately. We know that tuberculosis is not transmitted from mother to child before birth, ordinarily at least. Inasmuch as it is due to a specific organism it is not inherited. Yet different families living under the same environment show a different degree of resistance to it. Inasmuch as we are all certain to be exposed is it not the part of wisdom to combine non-resistant with resistant stocks as far as possible?

Positive eugenics involves the attempt to improve the race stock by the greater care in the selection of life-partners. At present this is an ideal rather than a movement. It is generally misunderstood and ridiculed but one of these days will come into its own. To attempt to prohibit or compel the falling in love with a given individual is usually vain but it would seem possible to develop such standards that certain classes of people would be considered while others would not. As a matter of fact this is now done in many ways, but the basis of such discrimination is social rather than biological.

There is a marked difference between domestic animals and the human stock. The animals become more valuable to man as they become highly specialized. We breed them therefore for the qualities desired by us. Who shall determine what special types of humans are to be perpetuated? Do men exist for the sake of society, or society for the sake of men? We can imagine a civilization of specialized groups from the feeble-minded hewer of wood and drawer of water, the higher grade cook and housekeeper, the school teacher and lawyer, the musician

and inventor, up to the genius; each marrying and perpetuating his own qualities at the behest of some overlord, whose task it would be to keep the world going and maintain peace and order. We should have, however, a system of absolute slavery for most of the race. It is not likely that this ideal will appeal to us of today. We prefer rather a race of sound and normal men and women of general rather than specialized traits.

Recognizing then that any type of strength, like any type of defect, may be inherited, is this thing we call genius common or rare? Certain factors must be kept in mind in seeking an answer to this question. Disregarding for the moment the influence of the environment in producing genius, it is clear then that in all ages and places the general conditions of culture and the spirit of the people play a part. The great poets are those whose songs have come down to us in written form. How many equally great have been lost to us by the destruction of the records we know not. Neither do we know how many have lived, sung and died among peoples without written records. In all the ages past there must have been countless thousands of men and women of the highest possibilities — like him who invented the bow and arrow or the art of fire making. Others live in the records merely because of some accidental discovery or chance deed, who in reality were not to be compared to many of their associates. Yet others very likely are honored because they stole or appropriated that which makes them famous. If our history is so full of great men whom existing enemies tried in vain to suppress, what of those who were suppressed? Were they all inferior in equipment, or has luck played a part? Furthermore, let us not forget the tendency to centralize our explanation of some great move-

ment in one man, to the utter neglect of others perchance in reality equally important. In all ages we have sought for the great men and we usually find that for which we seek, or discover an acceptable substitute.

Francis Galton, to whose studies of genius all students are indebted, came to the conclusion that about 250 men out of a million really belonged in the class called distinguished. His conclusion would divide the million in the following fashion, as worked out by Ammon:[29]

| | | |
|---|---|---|
| Class X | 1 | Genius |
| G | 14 | |
| F | 233 | Talented |
| E | 2423 | |
| D | 15696 | |
| C | 63696 | |
| B | 161279 | |
| A | 256791 | |
| a | 256791 | |
| b | 161279 | |
| c | 63563 | Poorly equipped and not useful. |
| d | 15696 | |
| e | 2423 | |
| f | 233 | |
| g | 14 | |
| x | 1 | |

On examining Lehr's "Genealogy" of royal and noble families, containing some 3,312 names representing some 32,768 individuals, Woods found only 16 worthy of being placed in his two highest grades, 9 and 10. Ward however believes, on the basis of French studies, that these estimates are entirely too low, and would put the number at 2,000 out of every million. Even if we come to some definition of genius, it seems impossible to get any satisfactory estimate of its prevalence at the present time.

This introduces another great question into which we cannot enter in detail. Galton and the older students made genius and fame practically identical and thus were

[29] REIBMAYR, A., quoted by, Inzucht und Vermischung, p. 246.

led to place all the emphasis on heredity. Woods tried to avoid this danger by studying the royal families only where all members were known and could be graded with some accuracy. Yet he came to much the same conclusion. "The upshot of it all is, that as regards intellectual life, environment is a totally inadequate explanation. If it explains certain characters in certain instances, it always fails to explain as many more; while heredity not only explains all (or at least 90 per cent) of the intellectual side of character in practically every instance, but does so best when questions of environment are left out of the discussion." [30] In a later essay Woods has considerably modified this verdict.

"But heredity is not everything, and I will give but two illustrations which show the possibility of separating out environment. Professor E. C. Pickering and myself have recently been measuring the scientific activity in the history of the world, and especially in the natural and exact sciences, by studying the elections to academies and the inclusion of names in the standard English, French and German encyclopedias. It appears that the increase in the total number of men engaged in science in Germany during the nineteenth century surpasses the expectations of heredity, and therefore must be due to something else — something we must call environment. Also, I have unpublished material showing that the proportionate number of women, as compared to men, whose eminence makes them noteworthy, has increased measurably in the United States from the first settlement of the country to the present day." [31]

Against the popular idea that genius rises above the

[30] Woods, F. A. o. c., p. 286.

[31] Woods, F. A., in Problems in Eugenics, p. 252 ff.

handicaps environment may offer and overcomes all obstacles, there are many evidences. "The trend of the whole investigation has been in the general direction of showing that great men have been produced by the cooperation of two causes, genius and opportunity, and that neither alone can accomplish it. But genius is a constant factor, very abundant in every rank of life, while opportunity is a variable factor and chiefly artificial. As such it is something that can be supplied practically at will. The actual manufacture, therefore, of great men, of the agents of civilization, of the instruments of achievement, is not a utopian conception but a practical undertaking." [32]

This quotation is taken from "Applied Sociology" by Lester F. Ward, in which is to be found the most careful and critical examination of the evidence on this subject with which the writer is familiar. It is particularly valuable because it puts in available form a digest of an important and little known work by a French student, Odin.

Odin found, on studying the French men of letters during a period of several centuries, that neither density of population, nor race, nor social position were determinative; but rather opportunity. As he puts it: "We have thus arrived, by a series of careful approaches and eliminations, at the conclusion that the fecundity of the respective localities in remarkable men of letters rests essentially upon the educational resources that they place within the reach of their occupants." [33] About 98 per cent of the men had enjoyed exceptional training and opportunity in childhood as well as in later life. Odin does not make

[32] Ward, L. F. Applied Sociology, p. 220.
[33] Ibid., p. 213.

Galton's mistake of ignoring the women, and he finds the same rule to hold. Over half of the women writers of note came from Paris where the greatest opportunities were offered. Clarke comes to similar conclusions in his study of American men of letters.

One needs only to consider the growth in the United States in the last century, the marvelous inventions and discoveries, the tremendous strides, not only in providing education for women, but their advent into fields hitherto closed to them (not only because of their sex but also because of their reputed inability to do the things done by their brothers) to realize that talent, whether rare as Galton thought or common as Ward believed, must develop in accord with opportunity.

Heredity then furnishes the basis and sets the limits to the development. Environment must furnish the stimulus and the opportunity. Heredity determines what a man may become, but environment determines what he does become. Here biology has one great lesson to teach. Problems of heredity cannot be solved by changing the environment, nor can society wait for some happy variation ere it utilizes the new factors in its own surroundings. The feeble-minded child may be trained to the limits of its capacity but it never becomes normal nor are its children improved. The various factors that enter into that complex we call social progress, will be elsewhere considered.

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## CHAPTER VII

### RACE DIFFERENCES

To the superficial observer all birds of a given species look alike. In reality they are not alike and it is possible to subdivide the species into many classes or races by grouping together those having the given characters. Our common little screech-owl sometimes has a reddish plumage, sometimes gray plumage, even in the same locality; but apart from color the two seem to be identical. The beautiful woodpeckers known as flickers or yellow hammers have a golden-yellow cast of plumage in the eastern part of North America. In the west, however, the yellow feathers are replaced by red plumes and the bird is given a very different appearance. Again, aside from this we cannot distinguish them, and every combination exists from the extreme yellow type to the extreme red. The same is true of meadow-larks, blackbirds, many warblers, tits and tanagers as well as of such different animals as squirrels, foxes and bears. Because of our recognition of these races or subspecies, exact classification is in many ways more difficult than it was in the days of Linnæus.

In earlier days it was supposed that such variations as were known had been directly caused by conditions of soil and climate. Now, as we have seen, the evidence is against this idea, and we have come to believe that variation has been produced by new germ cell combinations. It may still be true that some of these mutants are better

fitted to survive under given conditions and will therefore have an advantage over other types and tend to replace them. In other cases the character in question seems to have no possible significance in so far as survival is concerned. We can see no difference in the yellow and the red types of flickers in so far as strength or fitness to exist is concerned. They are different, that is all. When we turn our attention to the human species we find the same phenomena.

"The genus *Homo* has but one existing species: *Homo sapiens.* And this species . . . is fairly divisible into four subspecies, all of which are so fertile in their cross-breeding with one another that they have in the course of time given rise to many transitional races and intermediary types, so much so that only about two-thirds of the living peoples of today can be decisively allotted to one or other of the definite subspecies. The remaining third comprises the long-established mongrel, hybrid races formed by the mixture of some or even of all of these four divisions of the existing human species. These distinguishable subspecies are:

1. The Australoid, nearest of all living men to the ancestral *Human,* to the paleolothic man of Europe and North Africa; and to the possible parent thereof — *Homo primigenius,* the man of Neanderthal and Heidelberg, of the Corrèze, of Spy, Krapina, and Gibraltar.
2. The Negro.
3. The Caucasian or European, possibly descended in a direct line from the Australoid or basal stock, with which in any case it is closely allied.
4. The Mongolic or Asiamerican.

"An ancient mingling of (1), (2), (3) and (4) has produced the *Polynesian* type; of (2), (3) and (4) — (4) predominating — the Japanese. The *Amerindian* peoples are mainly descended from an early branch of Mongolic mixed with Proto-Caucasian; there are many tribes in the Malay Archipelago that are half Mongol, half Negrito (Asiatic Negro); the natives of Madagascar are a mixture of Mongolic-Polynesian and Negro. Negrito and Australoid in varying degrees of intermixture have produced the Tasmanian negroids and the Papuans. The aborigines of Ceylon (Veddahs) and India (Dravidians, Todas, etc.) are on the borderland between Australoid and Caucasian with (here and there) a touch of Negrito or Mongol. Some of the Central Asians or North Europeans are Caucasians crossed with Mongols, the two strains being either evenly balanced or one of them predominating. The proud peoples of Western and Southern Europe and of North Africa, of Syria, Arabia and Persia, are principally composed of Caucasian tinged very slightly or considerably with ancient or modern Negro, or Australoid (Dravidian) blood; the war-like tribes of Northeast Africa are half Caucasian, half Negro. The very Negro himself is scarcely of unmixed subspecific rank, except in his extreme Bushman-Hottentot, Pigmy and West-African Forest types. Elsewhere a meandering rill of Caucasian — perhaps even of Australoid — blood permeates Negro Africa and Negrito Asia." [1]

There is a very widespread confusion as to the meaning of the word *race*. It should be used as above indicated to apply to groups of people who may be distin-

[1] JOHNSTON, H. H. The Negro in the New World, pp. 1–2.

guished from each other by certain physical traits. With the possible exception of the Eskimo, the inhabitants of America when the whites first came here were all of common stock and we may properly speak of an Indian race. In language, institutions and laws, they differed as much as did the north-Europeans of whom Cæsar wrote. The Germans, in spite of the claim of Tacitus that they were a pure, unmixed people tracing their descent from one god, were a mixed people descended from various stocks; and it is incorrect to speak of them as a race unless the term is limited to some definite part of the people. There were Aryan peoples speaking related languages but there was no Aryan race. Common language, culture, residence and nationality do not preclude differences in race. Nor does inclusion in the same race preclude individual differences which may be, and often are, quite as great as those which separate the races themselves. We are here considering, not these personal differences, but those between groups of individuals.

Whether there is any relation between the physical peculiarities which may exist and civilization is another and very different problem, and the student must be warned at the outset not to confuse the two. Deeply ingrained in human nature is the tendency to believe that we and our own ancestors have been and are superior people. Our men are the finest, our women the most beautiful. We come to prefer our own traits, to consider them as highest and best, and to forget that other groups have like notions and hence different standards. First then let us see what differences are to be found, and later consider their significance.

Color is perhaps the first character to attract attention.

In the human being this ranges from black to white and depends upon the amount of coloring matter in the pigment cells of the skin, hair and eyes. The color of hair and eyes varies more in the white groups than in all others. The eyes range from very light blue to dark brown, the hair from flaxen yellow to black. Outside the white group the hair is brown or black and the eyes are always brown. Roughly speaking we may divide living men into four groups:

1. Black: Negroes just south of the Sahara, and in a few isolated spots in South Africa: Melanesians.
2. Chocolate: through coffee and olive to reddish-brown: the American Indians, Polynesians.
3. Yellow: (dull leather to muddy white): most of the Asians, northern Africans, Hottentots, Bushmen, Eskimo, Lapps, Malaysians.
4. White: (some groups verging towards yellow or brown): Europeans, some Asians, Ainus of northern Japan.

"The general rule is that eyes and hair vary together, both being either light or dark, as if in correspondence. Nevertheless, such ideal combinations do not characterize a majority of most European populations. Thus, in Germany, of six million school children observed on a given day, not one-half of them showed the simple combination of dark eyes and dark hair or of light eyes and light hair. . . . Even among the Jews, Virchow found less than forty per cent characterized by the same tinge of hair and eyes. In parts of Russia the proportion of pure types is scarcely above half; in Denmark, less than forty per cent were consistently pure." [2]

[2] Ripley, W. Z. Races of Europe, p. 65.

Barring the exceptional cases of dwarfs or giants the average stature of human groups ranges from four feet four inches to five feet ten inches. Ripley states that more than ninety-nine per cent of the human species is above the average height of five feet and one inch. The pigmy groups of the Congo basin are at the lowest level, but most of the Negroes are as tall as any other groups. Great variations in height are found in the same group. The Hottentots are taller than the Bushmen; the Creeks and Cherokees than the Pueblo Indians. The Scotch and white Americans are about as tall as the Polynesians — five feet eight or nine. There are parts of France where the average is but five feet two inches and where two-thirds of the men are below five feet three, while in other districts the average is much higher. It appears that favorable conditions of food and climate have much to do with stature and Americans have often been found to be taller than their European ancestors.

The hair ranges from the straight locks of the Indians to the tightly twisted kinks of some of the Negroes. The curling depends on the cross section, straight hair being nearly circular, while the more elliptical the cross section the greater the twist. There are also differences in the distribution of the hair, only the Australoids and Whites having hair on the back while some, like the Mongols, are almost beardless.

The nose varies from the narrow type of the White through the broader form of the Mongol to the broad, flat, depressed type of the Negro. There are also other differences less often observed. Such are the greater breadth of the Negro's chest and his narrower pelvis so that the body form of the sexes is almost the same. He has also

a greater development of the heel. There are also differences in the proportions of the body, in the length of arms and legs, in the structure of the skin, the deposition of fat, the curvature of the sacrum and the relative size of hands and feet, which with many other features cannot be considered in detail.

About the middle of the nineteenth century, European students realized that there were marked differences in the head forms of men, and that apparently these differences were very persistent and could be used as tests of race. The head is nearly always longer than it is broad, and by dividing the breadth by the length we get what is known as the cephalic index. The actual range of observed cases is from 62 to 103. Heads with an index under 75 are called dolichocephalic (long-headed); between 75 and 80, mesocephalic; and above 80, brachycephalic (round-headed). In the dolichocephalic division belong most of the Negroes, Papuans, Australians, Eskimo, the Corsicans and Portuguese. In the second are the Bushmen and Hausas in South Africa, Japanese, northern Chinese, many Polynesians and North American Indians, Flemings, Sicilians and Basques. In the brachycephalic division are Magyars, Walloons, Russian and Galician Jews, South Chinese and Mongols.

It is almost impossible to make any general classification of the Europeans or white Americans on this basis for all classes are represented. "Measurements on the students at the Massachusetts Institute of Technology are fairly typical for the Anglo-Saxon people. Out of a total of 486 men, four were characterized at one extreme by an index below 70; the upper limit was marked by four men with an index of 87. The series of

heads culminated at an index of 77, possessed by 72 students.

"The most conspicuous feature of our map of cephalic index for western Europe is that here within a limited area all the extremes of head form known to the human race are crowded together. In other words, the so-called white race of Europe is not physically a uniform and intermediate type in the proportions of head between the brachycephalic Asiatics and the long-headed Negroes of Africa. A few years ago it was believed that this was true. . . . In the high Alps of northwestern Italy are communes with an average index of 89, an extreme of round-headedness not equaled anywhere else in the world save in the Balkan Peninsula and in Asia Minor. This type of head prevails all through the Alps, quite irrespective of political frontiers. . . . Yet within three hundred miles as the crow flies, in the island of Corsica, are communes with an average cephalic index of 73. . . . Nor is this all. Pass to northern Scandinavia, and we find among the Lapps, again, one of the broadest-headed peoples of the earth." [3]

Ripley makes this difference in head form one of the bases of his classification of the European peoples. This is perfectly proper. Unfortunately, however, other students, believing that the north-Europeans had been the leaders in education and civilization and holding that they were preëminently long-headed, have made some very extravagant claims. Thus Ammon in a book in which he has really collected much valuable evidence delivers himself of this tribute to his ancestors:

[3] RIPLEY, W. Z. o. c., pp. 41–54.

"Like all the Aryans the Germans are born rulers of other peoples. Wherever they appear they are the ruling and socially dominant class. Mastery fulfills their longings and they spend their time in sports, hunting and fighting while the necessary physical labor is left gladly to the underlings or slaves.

"Of entirely different type are the mental characteristics of the dark round-headed groups. At the time of the 'folk-wandering' a dark, round-headed folk first appear in the light of history, the Huns. They appear as a race of horsemen from the Asian Steppes: hateful, wild, hideous, fond of booty and blood, cultureless, the terror of the western lands.

"Thus the long-heads of German descent appear as the bearers of the higher spiritual life, called by nature to occupy the ruling places as the born defenders of the fatherland and the social order. Their very nature destines them to the aristocracy. Only in slight degree do they possess any business sense. The round-heads on the contrary are in this regard well-equipped. Skilled in every agricultural and technical calling, like trade and finance, they are surpassing farmers, workers and dealers, but at the same time chiefly docile underlings. The gifted among them understand how to organize industrial enterprises and increase their property. Purely scientific pursuits which the long-heads eagerly follow with all the ardor of their natures are far removed from the round-heads, who, nevertheless, understand the practical value of the newer discoveries and are frequently able to bring the squandering long-heads into economic dependence. Their longing for the democratic philosophy of equality is based upon their own mediocrity and their own disin-

clination, if not hatred, towards greatness which they do not comprehend." [4]

Ammon seeks to find evidence for this in the present makeup of the German population. He finds that the city population is more largely of the long-heads and that the upper classes include few of the round-heads. Even if it be admitted that the facts are as stated — and many will not admit it — it is possible that there are other explanations, or that this explanation ignores other facts. This claim is one that can neither be proven nor disproven with the evidence at hand. Certain other facts must be considered.

Modern Europe has a very mixed population. As Ripley says: "In no other part of the world, save modern America, is such an amalgamation of various peoples to be found as in Europe. History, and archaeology long before history, show us a continual picture of tribes appearing and disappearing, crossing and recrossing in their migrations, assimilating, dividing, colonizing, conquering, or being absorbed. It follows from this, that, even if the environment were uniform, our pure types must be exceedingly rare. . . . We are thus reduced to the extremity in which my friend Dr. Ammon, of Baden, found himself when I wrote asking for photographs of a pure Alpine type from the Black Forest. He has measured thousands of heads, and yet he answered that he really had not been able to find a perfect specimen in all details. All his round-headed men were either blond, or tall, or narrow-nosed, or something else that they ought not to be." [5]

It is admitted that there have been many waves of con-

[4] Ammon, O. Natuerliche Auslese beim Menschen, p. 177 ff.
[5] Ripley, W. Z. o. c., pp. 107–108.

quering peoples sweeping over Europe and that present social strata were in part determined by such conquests. It might easily happen then that the last conquests were made by a long-headed race who occupy consequently a relatively higher position. To assert that this involves an inherent superiority of the long-head over the round-head is a very different matter.

If we apply this test to the various peoples on earth we find some curious combinations. "We are driven to place on the same level the Bushmen and the French of Roussillon, the Teleoutes and the French of the department du Nord, the Nahuquas of Brazil and the French of Perigord and Limousin; the Mordwa, the Tartars and the Votiaks, on the same level as the French in general, the most representative type of European thought and civilization." [6]

It must be confessed that there seems to be little evidence shown from every-day life of this alleged superiority. One can only wonder what men like Kant, Laplace, Voltaire, would have accomplished had they been long-headed instead of round-headed. In north Italy more long-heads are reported among the professional classes; in south Italy, more round-heads. Moreover, the claim of superiority for the long-headed raises the problem of accounting for the supremacy of the round-heads for long ages at various times in the world's history. There is no evidence that such superiority is manifested in the very mixed population of the United States today, though we must recognize that careful studies on this point are lacking. I think that Finot is justified in his final statements on this subject:

"A conclusion forces itself on us when we compare the

[6] FINOT, J. Race Prejudice, p. 64.

results obtained by the measurement of all parts of the head. It is that the skull, which is subject to variations, leaves an impression during its evolution on the face which is only its complement. Consequently, inasmuch as we no longer see about us any races which are clearly defined from a craniological point of view, it is impossible that there can be any such races from the point of view of the other measurements taken from the component parts of the head. The differences among individuals belonging to the same human variety are always greater than those perceived among races regarded as distinct units in themselves.

"The mixed type constitutes the salient characteristic of modern humanity, especially that of Europe. We shall see later on that this, being the result of a cross-breeding of nearly all the other races, must have with these many traits in common. This is particularly noticeable in the case of craniological variations." [7]

Much greater weight is added to these conclusions by the recent work of Professor Franz Boas which seems to show that the skull instead of being as all had supposed one of the most unchanging human characteristics is being modified under American conditions. Just how significant these observations are, only future study can show. Under his direction observations were made of 2,422 (males) and 635 (females) American born Hebrews and of 1,689 foreign born males and 1,253 females. Some Sicilians were also studied but the number is not given. Dr. Boas reports: "The head form, which has always been considered as one of the most stable and permanent characteristics of human races, undergoes far reaching changes due to the transfer of the races of Europe to Ameri-

[7] FINOT, J. o. c., pp. 88–89.

can soil. The east European Hebrew, who has a very round head, becomes more long-headed; the south Italian, who in Italy has an exceedingly long head becomes more short-headed; so that both approach a uniform type in this country, so far as the roundness of the head is concerned."

*Cephalic Index*

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"It appears that the longer the parents have been here the greater is the divergence of the descendants from the European type.

"The length of the head of the Hebrew is increased; the width of the head and the width of the face . . . are decreased.

"Among the Sicilians the changes are, on the whole, of an inverse order.

"I think, therefore, that we are justified in the conclusion that the removal of the east European Hebrew to America is accompanied by a marked change in type, which does not affect the young child born abroad and growing up in American environment, but which makes itself felt among the children born in America, even a short time after the arrival of the parents in this country. The change of type seems to be very rapid, but the changes continue to increase; so that the descendants of immigrants born a long time after the arrival of the parents in this country differ more from their parents than do those

born a short time after arrival of the parents in the United States." [8]

Many attempts have been made to find some relation between the angles of the head and mental ability. We are told that the prognathic groups represent more primitive, hence lower, types. These measurements are very uncertain. So Camper at the end of the eighteenth century thought that the human face ranged between 70° and 80°. "Everything which is above this comes under the rules of art, whilst everything which is below this resembles monkeys. If I raise the facial line forward, I have a classical head; if I make it lean backwards, I have the head of a negro." Again we have the highest and lowest groups in confusion. Broca made the angle for the New Caledonians 66.2, for Parisians 65.9, for the native Australians 65.6. The Bretons showed 68.5, the Auvergnats 67.9, the Negroes 68.6. Using the naso-basal angle of Virchow we find the Turks 64.3, the French 65.1, the Kalmucks 65.8, the Chinese 65.9 and the Germans 66.2. It is impossible to discover from these figures any relation between the facial angle and race development.

There are also differences in the size of the skulls and their cubic contents. It is difficult to make many comparisons or even statements owing to the fact that the actual number of skulls measured or brains weighed, is often meager. The cranial capacity of the Asiatic Negro has been put at 1260 c.c., of the Bushman at 1331, of the African Negro at 1388. These figures seem high for the cranial capacity of the European is put at 1360, and curiously enough this is no larger than that of the earliest discovered skulls of man. It is stated that the average

[8] Boas, F. Changes in Bodily Form, pp. 7 ff, and 52.
[9] Finot, J. o. c., p. 80.

brain weight of male Europeans is about 1380 gr., that of women, 1237. It is said that the weight of the male Negro brain ranges from 974 gr. to 1445, the average being about 1200 gr., while the average of the Negroes enlisting in the Union army was 1331. Again we are at a loss to know what this signifies. If absolute weight has any value the male Negro is more capable than the average white woman, a conclusion which many will hesitate to accept. The brain weight of dwarfs is said to be in some cases $\frac{1}{19}$ of total body weight, but dwarfs are not strong mentally. Among mammals the smaller the animal the larger proportionally is the brain. In the cat the brain is to the body as 1 to 106; in the lion, 1 to 546. Is the lion of lower grade mentally? Until we know more of the brain it would seem to be unsafe to draw any conclusions of inferiority on the part of the groups not now highly developed intellectually.

Within recent years, we have learned, that individuals show varying degrees of resistance to given diseases. This seems to be due to chemical differences in the blood. Whether this is distributed along racial lines is a matter of some doubt. Again this immunity may be only apparent and due to differences in mode of life and care of the body. As illustrative of the differences which seem to exist we may note: "The predisposition of the negro for elephantiasis and tetanus, his sole liability to the sleeping sickness, . . . his immunity from cancer and his liability to skin diseases in general, together with his immunity from yellow fever and bilious disorders, are well-recognized facts in anthropology. The Mongolian type appears to be likewise free from inflammatory diseases, and oftentimes from cholera to some extent; as well as from beri-beri, which is so peculiar to the Malay stock that it

may be traced in the Japanese kakké." [10] Consumption and syphilis appear to curse the white race to an unusual extent. To what extent this idea will be modified as we get fuller information is uncertain. It may well prove that there are differences but each race will seemingly have a sufficient number of diseases left to which it is heir that the death rate will be maintained.

It is likewise possible that the different races will be found to react in different ways to climatic influences. Thus the Negro with his larger sweat glands and his skin cool even under tropical conditions may ultimately thrive in the tropics better than the White and may continue to show a higher death rate in the temperate regions.

We have now hastily reviewed most of the race differences which have attracted the attention of students. In spite of popular opinion it does not seem possible to classify the races into higher and lower in so far as physique is concerned. In certain regards one group seems to have preserved more of the characters of our ape-like ancestors but in other regards the vaunted white race seems nearer the original stock. It would seem then that all that we can do is to classify the races on any basis that may appeal to us and leave for the future the determination of the question whether any of the things we find are in any way correlated to the development of the brain or the possibility of attaining a high degree of civilization.

The preferred basis for the grading of the human races into higher and lower is color. It so happens that the dominant civilizations of today are largely among the lighter colored groups. It is easy to assume that there must be some causal connection between these facts. The

[10] RIPLEY, W. Z. o. c., p. 568.

more carefully the facts are examined the more doubtful becomes the conclusion. In ages gone by there were great civilizations on the banks of the Tigris, the Euphrates and the Nile, in which the blond groups of today had little part. "The Elamites of Mesopotamia appear to have been a negroid people with kinky hair, and to have transmitted this racial type to the Jews and Syrians. There is a curliness of the hair, together with a negro eye and full lips, in the portraiture of Assyria which conveys the idea of an evident negro element in Babylonia. Quite probably the very ancient negro invasion of Mediterranean Europe (of which the skeletons of the Alpes Maritimes are vestiges) came from Syria and Asia Minor on its way to central Europe." [11]

The Chinese had developed a high civilization at a period when the ancestors of present day Europeans were savages. The dark Americans were about as far along in civilization when Columbus found them as were the Teutonic groups when first they came in contact with the Romans. In the light of history it may be that other factors than color of skin have caused the lighter groups to play such a prominent rôle just now. Possibly then in ages to come the darker groups will again find their place "in the sun." At all events until some one is able to put his finger upon some physical difference which can be shown to have some connection with the degree of culture or the possibility thereof, we have no right to assume that one group of human beings is either superior or inferior to any other. Indeed some of our best anthropologists tell us that if we give a fixed value to all the various parts of the body and then proceed to measure the various races

[11] JOHNSTON, H. H. o. c., p. 27.

we shall find one standing about as high as the rest on our ideal scale. That the minor physical differences, particularly color, may invite great differences of social treatment in a mixed society is not to be overlooked but that is another story.

Whenever we consider any great nation of which we have any considerable amount of information it seems clear that the race in control is far from being of common descent regardless of popular tradition. That Egypt, Greece, and Rome were composed of many elements is evident and there has hardly been a greater fiction in history than the so-called Jewish race. It is equally well known that modern Europe, as well as America, shows a similar mixture. Under the leadership of the German Anthropological Society an examination was made of some 10,000,000 school children in Europe as to color of hair, eyes and skin. Of these 6,758,827 were from Germany; 2,304,501 from Austria, 608,698 from Belgium and 405,609 from Switzerland. Of these, not counting Belgium, 25 per cent were fair-haired, 15 per cent were brown-haired and about 60 per cent mixed. Germany showed 31 per cent fair-haired, 14 per cent brown and about 55 per cent mixed. In Scotland 1,100 Highlanders, who might have been expected to be brown inasmuch as they were Celts, showed 45 per cent fair-haired, 30 per cent brown and 25 per cent mixed. One thousand two hundred and fifty Viennese gave 32 per cent fair, 23 per cent brown and 45 per cent mixed. One has only to read Ripley's "Races of Europe" to see what tremendous mixtures there are on that Continent, or to consult the reports of the Commissioner of Immigration for similar facts relating to the United States. Admitting then the scarcity of what may be called

"pure races" of mankind and admitting further the fact of constant crossing, can we get any evidence as to whether such race intermixture is good or bad?

Here again we are confronted with the difficulty of distinguishing evidence based on fact from that resulting from prejudice. Human opinion on this subject swings between the two extremes of objecting to all race crossing on one side to the advocacy of intermarriage on the other. A little thought will show that the marriage of two persons of markedly different races is likely to produce difficult social questions regardless of the physical traits of the offspring. It would seem then that the violent opponents of race-blending, while basing their arguments on its alleged bad results, physically speaking, really have the social confusion in mind while those advocating such crossing make the opposite mistake. The latter see little reason to fear bad physical results and shut their eyes to the social questions.

So we may glean from a work purporting to be scientific the following sentences. "Nature prevents the development of the mongrel; in the few cases in which nature has for the time being successfully been outraged and a mongrel produced, nature degrades that mongrel mercilessly and in time stamps it out. Nature suffers no mongrel to live. . . . The intermarriage of people of one color with people of another color always leads to deterioration." This writer's antipathy to race crossing is carried so far that it classes the people of German and English stock as incompatible. "It is clear that the two people had developed into two distinct races, and the development of fifteen hundred years cannot be undone in America any more than anywhere else. It follows that they can no longer cross promiscuously with impunity. Promis-

cuous crossing of the two races will lead to the deterioration of both, and as they are the best two races that the world has, the degeneration of even a few of them is an inestimable loss to the world." [12] America, therefore, is doomed to an early decay because of the influx of many peoples. Curiously enough in the entire volume no evidence based on physical facts is offered, but the author depends solely upon evidence from social customs, etc. Now inferiority must have a physical basis. If it is so clear and all-pervasive it must be possible to discover some of it.

There are, however, those who hold the opposite viewpoint. "It is known that a race injures itself by inbreeding and that it improves itself by crossing . . . The crossings are then indispensable for augmenting the vigor of a race. . . . Crossings have such incontestable utility that they should be encouraged as much as possible. In our own day a number of societies, civilized as well as barbarous, strive to prevent crossings. They but cause the greatest of all evils — the degeneration of the race." [13] If, however, we turn aside from the rhetorical arguments and seek to find the physical facts which would justify us in deciding this question we shall be surprised to find how little tangible evidence there is and how hard it is to interpret what we find.

Lapouge is one of the few who have sought to collect the facts, and, let us not forget, he is a great protagonist of the theory of the inherent superiority of the dolichocephalic blondes. He believes his studies warrant him in claiming that race-crossing results in the production of all sorts of disharmony in the body. We have such asym-

12 Schultz, A. P. Race or Mongrel, pp. 14 and 298.

13 Novicow, J. Quoted by Lapouge: Les Selections Sociales, p. 158.

metrical phenomena as the varying tone of color between the two eyes; the differences in color of the hair on the right and the left side of face and head, the dissymmetry of the nose, the combination of round heads and oval faces or of round faces and long heads found among many of the European groups. He holds that similar disharmonies exist in the internal organs and specially emphasizes the asymmetry of the uterus as of great importance because of its effect on reproduction. "Reversion is the rule when the two types are not very different; otherwise it becomes the exception, and the extinction of crosses of widely separated breeds results from their infertility. . . . Ordinary crosses have, in general, a greater tendency to reversion than to sterility, but, in the great majority of cases, they are less fecund than the primitive stocks, and that infecundity comes through the crossing." [14] This asymmetry of the uterus he believes results most frequently in the crosses of the long-headed European type with the round-headed Alpine race. This he considers one of the most potent causes of the decline of population in France where he believes that in general 10 per cent of the women are sterile. This sterility rises in the districts of the greatest intermixture to perhaps 25 per cent and falls in some of the secluded and purely Alpine regions to 3 per cent. Probably there goes along with this a production of defective germ cells. The hybrid also has a lowered vitality and greater mental instability. "The superiority of the Yankee, the English, Dutch, Scandinavian over the French, Italian, Spaniard, South-American is not solely the result of their superiority of race, but also of the purity of blood. The first are of the European race and are

[14] LAPOUGE, G. V. Les Selections Sociales, p. 170.

practically pure, the others have less of the European race blood and their inferiority corresponds to the degree of race mixture." [15] The French departments showing the highest birthrate are those in which the percentage of long heads is greatest; those showing the lowest, the reverse. All that can be said of most of the disharmonies cited by Lapouge is that they are departures from an esthetic standard preferred by him. His statement with reference to the asymmetry of the uterus is very significant if true. The only difficulty is that other observers do not seem to substantiate his position and that it is rendered very doubtful by certain historical facts shortly to be mentioned.

Another source of information is the physical record of the Negroes and mulattoes who enlisted in the Union army at the time of the Civil War.

*Weight of Brain of White and Colored Soldiers*

| *No. of cases* | *Degree of color* | *Weight of brain* |
|---|---|---|
| 24 | Whites | 1424 grammes |
| 25 | Three parts white | 1390 grammes |
| 47 | Half white | 1334 grammes |
| 51 | One-fourth white | 1319 grammes |
| 95 | One-eighth white | 1308 grammes |
| 22 | One-sixteenth white | 1280 grammes |
| 141 | Pure negroes | 1331 grammes [16] |

It seems difficult to draw any conclusions as to inferiority or superiority of the mulatto from this table based as it is on only a very few cases, yet some have not hesitated to claim that it shows his marked intellectual superiority. Dr. Gould found among the soldiers the following differences:

[15] LAPOUGE, G. V. o. c., p. 184.

[16] HUNT, S. B. The Negro as a Soldier, *Anthropological Review*, vii, p. 1869.

| | *White* | *Negro* | *Mulatto* |
|---|---|---|---|
| Weight | 140 | 143.8 | 145.1 |
| Chest girth | 35.4 | 35.8 | 35.7 |
| Capacity of lungs | 187.8 cu. in. | 165.3 | 161.6 |
| Rate of respiration | 16.4 | 17.7 | 19. |
| Pulse rate | 74.84 | 74.02 | 76.97 |
| Head circumference | 22.1 | 21.9 | 22. |
| Facial angle | 72. | 68.8 | 69.2[17] |

On these figures Dr. Hoffman comments: "We have, therefore, the contrast of the mulatto being physically and perhaps morally the inferior of the pure blooded negro, while intellectually he is the superior." [18]

In considering these statements we must recognize that there has been little effort made to get detailed and accurate information on the questions involved and that possibly certain differences in social conditions may account for the varying results. It is worth while to note that the number of Negro-White cross-breeds in the country today cannot be far short of the whole number counted as Negroes at the close of the Civil War, or from one-fourth to one-third of the total. The teachers in our schools do not find marked differences between the full-bloods and the mixed. The leaders of the Negroes in America like Booker Washington and W. E. B. DuBois are mixed-bloods while others like Kelly Miller and R. R. Moton are pure Negroes. Whenever we are told that a people of mixed white and Negro blood must perish from earth let us not forget that across Africa in the Sudan and down the East Coast there are untold millions of people of just that descent. Such facts as Johnston calls attention to are often overlooked:

"The Negro was soon followed up in his appropriation of Africa by the Caucasian of an already negrified Mediter-

[17] GOULD, B. A. Military and Anthropological Statistics of American Soldiers.

[18] HOFFMAN, F. L. Race Traits and Tendencies, p. 186.

ranean type: Libyans wandered across the Sahara, dispossessed the red-skinned pygmies of western Nigeria, absorbed some of the Forest Negroes, and formed such hybrid stocks as the Songhai, Mandingo, Fula, and Nyamnyam, Hamites (Egyptian and Gala) occupied Egypt from Arabia and pushed westwards across the Libyan Desert, mingling freely with long-legged or short-legged and prognathous Negroes, and thus called into existence mixed races like the Tibbu, Nubian, Ethiopian, Masai, Andorobo, Hima, Gala, Somali, and Danakil.

"There has been much infiltration of Caucasian blood from Europe and western Asia in more recent, historic times. Pre-Islamic Arabs undoubtedly . . . were connected with and settled in Southeast Africa perhaps more than two thousand years ago. They must have taken to themselves concubines from the South African Negroes, and these last — possibly not yet 'Bantu' in speech — may have already created the Hottentot hybrid with the Bushman in Southwest Africa. Then from A. D. 1000 onwards came many Arabs, Persians, Baluchis, and Hindus to the East African coast. From out the mingling of all these elements in different degrees arose the African peoples of today, very few of which are without some tinge of Caucasian blood due to the White man's persistent invasion of Africa from — let us say — 12,000 B. C. to the present day." [19]

The fact is wherever we turn on earth, explain it as we may, that evidences of uniformity of descent are only found in outlying, remote and rather inaccessible regions and that nowhere under such conditions has any great civilization developed. On the contrary, whenever we turn to the great nations of the world we find every indi-

[19] JOHNSTON, H. H. o. c., pp. 29–30.

cation of race mixtures far exceeding the popular belief of the people themselves. Whatever the future may disclose there is now no evidence worthy of credence to show that the intermarriage of even the most widely separated races results in physically inferior offspring. This statement is by no means to be interpreted that the fusion of the races is always wise or desirable. Whether favored or not, whether prohibited by law or not, it is taking place. Endless statements could be cited either for or against the action. Because of the strong feeling in America against the marriage of whites and Japanese the following statement attributed to Professor Baelz, a German physician at the Tokyo University, is worthy of notice.

"On this question I may speak with a certain degree of authority, having been the first, and in fact up to this day the only scientist, who has made a special study of the comparison of the physical qualities of the Japanese and European races. Besides, as a physician in Tokyo during thirty years, I have had the opportunity of examining an unusually large number of (Eurasians), and I have paid particular attention to them. The result of my observations is that they are a healthy set of people, and I do not hesitate to say that no one of the common arguments against them is supported by science. They are on the average well built, and show no tendency to organic disease more than Europeans or Japanese do. This is the more remarkable as many of them grow up under unfavorable circumstances, the father often having left them with little money to the care of a mother who has no authority over them. This is a particularly important point if the moral qualities are considered. In Europe too, we know that abandoned illegitimate children very often turn out badly, and a fair comparison must take that into serious consider-

ation. To make quite sure about the intellectual and moral qualities of the (Eurasian), I have asked the opinion of the man who is more than any other qualified to give an authoritative judgment — Mr. Heinrich, director of the School of the Morning Star. He has had in his classes, side by side, Europeans, Japanese, and almost all the male half-breeds in Tokyo. His opinion is, that if properly brought up and well-looked after, the half-breeds are morally, and intellectually in no way inferior to the children of both races. As a rule they are taller and more robust than the Japanese, and in every branch of learning they are fully up to the standard of their fellow-scholars." [20]

The attempt to build a biological foundation for the walls of race prejudice has been most unsuccessful, it seems to me. In the opinion of the Whites a Negro is a Negro, and a mulatto is a Negro, but biologically he is not. The Jews are persecuted and repressed in Europe and are discriminated against in America in many ways but their social inferiority is not the result of physical or mental inferiority. Biologists warn us that there is no reason to anticipate the production of a superior type by crossing two species. They forget that this has happened more than once in the history of animal breeding, and they forget further that domestic animals are specialized as human races are not. Moreover, there may be social advantages even if the biological results are unimportant. In America there seem to be but two solutions to our great race problem. The one is amalgamation. The other is a caste system much like that of India with its denial of opportunity to the lower castes, the consequent destruction of democracy, and the downfall of Christianity as now understood at least. Can there be enduring peace unless

[20] LAWTON, L. The Empires of the East, Vol. II, p. 772 ff.

Jew and Gentile intermarry? I am not attempting to solve our race problems. I am merely trying to indicate that there is much more involved in them than the mere desire to preserve the purity of the stock on the one hand, or the emotional wish to extend social equality to a group as yet inferior on the other. The intermarriage of two individuals of two races must be considered in the light of their own qualities just as if they were of one group. In other words there are individuals of all grades in all groups. The obvious social difficulties which grow out of the marriage with one of a socially inferior group are enough to make any wise person hesitate before he imposes such a handicap on his children. Particularly is this true when some physical trait like color will serve to mark out the child regardless of its other characteristics. No thoughtful person, then, it seems to me, can today advocate the intermarriage of white and black as a solution of the present difficulties. On the other hand why decree by law that the thing may not occur when it is perfectly possible that in years to come such intermarriage will seem both natural and desirable? Just such a change of sentiment has come as regards the Indian.

There now remains to be considered some of the attempts to classify the various human races. This might be done on a basis of language or any other social institution. We are, however, primarily concerned with the physical side of man so may disregard the other bases. Evidently a complete and accurate classification was not possible before the nineteenth century because of the extent of ignorance of other parts of the world. Indeed it is not entirely possible today. When man appeared, where, whether in one or many places, we do not know. His early wanderings cannot be traced. We know little of

the early mixtures that took place, hence we must depend upon the presence of characters which seem persistent.

Earlier peoples were not greatly concerned with outsiders. They called them "barbarians" or "gentiles" or names of like import. They thought that they had been created by other gods and were probably inferior peoples. They thought all sorts of monsters existed only a few miles away from their own centers and sometimes they described them in detail, though not always with accuracy. Indeed the word race was hardly used until the time of Buffon, in the eighteenth century, who employed it to designate a variety developed under the influence of soil and climate and changing as they changed. We are not surprised then that the first classifications were defective.

One of the oldest, taught even today in some places, was based upon the account of the flood and the survival of the three sons of Noah. Shem became the ancestor of the Semites, Ham was the progenitor of the Negroes who were compelled by his sins to have dark skins and be "hewers of wood and drawers of water" while Japhet started the long line of the rest of us, and in some vague way most of the rest of us were Aryans.

Linnæus divided mankind into three great sections: *sapiens* (educated or civilized); *ferus* (wild), and *monstrosus* (monster). Among the *sapiens* he put the European, whom he describes as light with fair hair and blue eyes and as active, shrewd, inventive, fond of closely fitting garments and respectful to the authority of law; the American, reddish in color with black hair and beardless, stubborn, contented, fond of liberty, who paints his body and is ruled by habit; the Asiatic, with yellowish color, dark hair and brown eyes, whose character is cruel and avaricious, fond of show, likes to dress in flowing garments and

is ruled by prevailing opinions; and the African, with his black woolly hair, flat nose and thick lips, who is cunning and indolent, greases his body and is governed by despotism. His conception of the ferus or wild man was apparently gotten from the stories of children who had been taken and reared by animals while his knowledge of monsters is equally vague. Among the last he puts (1) the inhabitants of the Alps who are small, active and timid; (2) those having but one testicle, the Hottentots; (3) the beardless, many American tribes; (4) those with deformed conical heads, the Chinese; and (5) the oblique-headed with skulls flattened in front, the Canadians.

A little later Blumenbach used the word Caucasians to designate the white colored peoples who had originated, as he thought, in the Caucasus Mountains. He made a classification, which with some modifications is still in common use.

1. The Caucasians: white-skinned, with red cheeks, brown, or brownish hair, round skull, oval face, smooth forehead, narrow, slightly aquiline nose, small mouth, perpendicular front teeth, face symmetrical and agreeable. All Europeans except the Finns and Lapps; Asians to the Caspian, Obi and Ganges and north Africans.

2. The Mongols: yellowish sallow skin, straight thin hair on the head, almost square skull, nose small, upturned, narrow eyes, projecting cheek bones. All Asians except the Caucasians and Malays, Finns, Lapps and Eskimo.

3. The Ethiopians: dark brown skin, dark curly hair, long heads, broad nose with upper jaw prominent, protruding lips. All Africans except those of the north.

4. The Americans: copper color, thin straight black hair, face broad but not flat, skull often deformed. All Americans save the Eskimo.

5. The Malays: chestnut brown skin, black hair, thick and curly; broad nose with thick lips, upper jaw slightly projecting. Malay Peninsula and many of the Pacific Islands.

Such a scheme has definite merit. The groups are few in number and they roughly correspond to certain superficial physical traits like color and to great geographical areas. Cuvier held to three main groups with many subdivisions, while Leibnitz and Kant compromised on four. Agassiz later placed the number at nine and more recent students have claimed that one or two hundred groups would have to be recognized.

St. Hilaire tried to introduce a new basis by classifying men as orthognathic (oval face with vertical jaws, i.e., Europeans); *eurignathic* (high cheek bones, i.e., Mongols); *prognathic* (projecting jaws, i.e., Negroes) and *eurignathic* and *prognathic* (i.e., Hottentots). F. Mueller sought to find a basis in the hair, making the first division the *ulotrichi* (woolly-haired) and the second the *lesotrichi* (straight-haired). It is interesting to note that recently considerable attention has been paid to the hair under the belief that it is one of the very persistent characters.

Huxley admitted four types:

1. The Xanthochroic type: fair with blue or gray eyes, bearded, with much hair on body. Most of Europe, the southern part being filled with brunettes, a cross with some darker type while in the East there is a Mongolian cross.

2. The Mongolian type: short, thick-set, brown skin, black hair, scanty beard, pronounced round skull, small nose, oblique looking eyes. Entire region east of a line from Lapland to Siam. Different types are the American Indians (long-headed), Chinese and Japanese, and Polynesians, probably the results of crosses.

3. The Negroid type: eyes and skin brown or black, hair usually black, short and woolly, projecting jaw. Sahara to Cape of Good Hope.

4. The Australian type: long-headed, prominent eyebrows, unusually large teeth. Tall; skin, chocolate brown; black hair, long and woolly. Australia, Deccan and Hindustan.

It is worth while to present one of the most recent classifications in more extended fashion and for this I have selected that of Professor F. H. Giddings of Columbia University.

I. The Australian-African Group.
   Characteristics: black skin, long-headed, jaws projecting, woolly hair, elliptical in cross-section.
   Area of distribution: Australia and Africa south of the equator.

II. The Polynesian-European Group.
   Characteristics: fair skin, skull neither markedly long nor round, jaws straight, straight or wavy hair, slightly elliptical in cross-section.
   Area of distribution: broad zone from Polynesia north westward through southwestern Asia and northern Africa and most of the continent of Europe.

III. The Asian-American Group.
   Characteristics: yellow or red skin, brachycephalic, narrow-eyed, lank or straight-haired (cylindrical in cross-section).
   Area of distribution: eastern Asia and western America, chiefly north of the equator along the semicircular shore-line of Asia and America.

"The Polynesian-European group occupies at the present time that zone of territory which extends from

Java on the southeast to the valley of the Thames on the northwest. In this zone the traces of earliest man have been found. If these traces indicate that this region was his original habitat, then man spread over the earth starting from this zone. If contingents of the original race wandered from this zone into new localities, and were prevented from crossing by environmental barriers they would become different from the original type, the one having wandered north into a colder clime, the other south into a warmer clime. . . . This we find to be true. The round-headed, lank-haired peoples of the North are separated by an intermediate type from the long-headed curly-haired peoples of the South.

"Now by the same reasoning, the original group, the intermediate and plastic type, would become in some way differentiated according as part went southeast and northwest, and these northwestern and southeastern groups would tend to differ somewhat although transmitting the characteristic head form. That is, different sections of the same general racial group would show slight variations from the stable peculiarities of the larger racial groups of which they were parts. This has been the case. In the southeast the brunette of southern Europe becomes the brown in Polynesia, while in the northwest the prevailing white of Europe becomes the pronounced blond of the Baltic regions. In the far southeast, the characteristics of long head and kinky hair are more extreme in Australia and Tasmania, because of long isolation. Also in the other direction there are blacks with long heads and kinky hair, blending off in Africa to the Polynesian type from interbreeding. . . .

"The European part of this race may be divided into two main divisions. One of these is relatively long-

headed and dark-complexioned; this division has been called the Eur-African group. The other is relatively round-headed, light-complexioned, and inhabits Europe west of the Ural Mountains, and Asia immediately east of the Ural Mountains; this division has been called the Eur-Asian." We may classify these as:

"I. *The Eur-African Race* (relatively long-headed, blond to dark complexion).

1. The Baltic Race. Characteristics: light blond type, very light hair and blue eyes, long head and face, tall stature, narrow aquiline nose.

   Area of distribution: the section of northwestern Europe near the Baltic Sea,— the general area inhabited by the Teutonic peoples.

2. The Mediterranean Race. Characteristics: brunette type, hair dark brown or black and eyes dark, head and face long, medium and slender stature, rather broad nose.

   Area of distribution: in southern Europe south of the Pyrenees, along the southern coast of France and Italy, including Sicily, and Sardinia.

II. *The Eur-Asian Race* (relatively round-headed).

1. The Alpine Race. Characteristics: chestnut hair with hazel gray eyes, round head and broad face, medium stocky stature, and variable but rather broad, heavy nose. (A type intermediate between the Baltic and the Mediterranean.) Its peculiarities appear most frequently when the type is found in greatest purity, isolated in a mountain area. The ancient Alpine race may have been exterminated in the lowlands and the

remnants driven into the mountain fastnesses by the energetic Baltic race.

Area of distribution: central France and the southern Alpine highlands.

2. The Danubean Race. Characteristics: blond, often red-haired, blue-eyed, round head and relatively broad face, of tall, heavy build. This race has played a most important part in history, variously called the Acheans, the Hellenic Greeks, and the Belgæ.

Area of distribution: the northern Alpine highlands, and the entire Danube Valley." [21]

To understand Giddings' scheme certain assumptions must be kept in mind. He believes that the white group represents more closely than any other the primitive undifferentiated type of humanity. Hence we find a great medley of characters in the group today, and hence this group has always been more subject to variation than the others. The black and yellow types have split off from the parent stock at some early time and have through natural selection in favorable environments developed their peculiarities.

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## CHAPTER VIII

### SEX DIFFERENCES

In all ages and places the human race has thought of itself as divided into two great groups, male and female. This dividing line of sex not only runs through the physical organs and functions, but extends into the fields of work, of play, of education, of government, of religion, and is not infrequently to be traced in the forecasts of the future life. So many of our emotional interests have come to center about sex, so many traditions and superstitions, so much prejudice and nonsense find their basis and support therein, that the student who would separate the chaff from the wheat and learn to what extent popular ideas are supported by the facts has a task of almost endless difficulty before him. How hard this task is will be quickly realized by the one who makes the attempt. He will find that a very large part of that which is offered as evidence is so clearly the product of preconceived ideas that it cannot be taken seriously. Much of the rest is so plainly based upon one or two cases that it is not safe to trust it. Moreover, the distinguishing of things resulting from physical nature and those due to social customs and standards is often impossible. Finally, within the last decade biology has compelled the acceptance of a new attitude towards many matters which formerly seemed settled, and sufficient time has not yet elapsed for a review of all the older evidence. It must be recognized then that many of the statements here made are to be considered as tentative and probable, rather than certain and final.

To the average man the division into sexes seems so definitely a fixed scheme of nature that it comes almost as a shock to learn that in thousands of the lowest forms of life there is no such phenomenon. After a time nature seems to be experimenting to see if it offers any advantages. Plant lice have a generation in which both sexes are present and then several in which the males are missing. The hickory phylloxera has a peculiar history. In the spring females only appear and lay their eggs in a leaf ball. These eggs may be either large or small but only one sort comes from a given individual. From the large eggs females are hatched; from the small, males. After fertilization these females lay the large eggs which last over winter to renew the cycle in the spring. Other forms, like earthworms, snails and leeches, are hermaphroditic, and this condition is believed to occur in animals as high as birds and mammals. Curious and bizarre combinations exist such as the blending in one individual of the characters of both sexes, known as gynandromorphism, which is found in insects, occasionally, and birds, rarely. In such a case one side of the body has the color and other characteristics of the male; the other side, those of the female. A bullfinch has been taken with a line on the breast sharply separating the red feathers of the cock on one side from the brown feathers of the hen on the other. Neither side was sexually perfect. It has already been mentioned that the unfertilized eggs of bees develop into drones, the fertilized eggs into workers and queens. Though true hermaphrodites are not found in the highest types of life, there are all sorts of imperfect combinations and malformations which remind us of earlier forms. We are forced to the conclusion that the bisexual forms offer some marked advantages over the uni-

sexual forms, and it would seem that these lie in the possibility of combining various strains of ancestry.

If we accept the suggestion that sex is determined by the presence or absence of given determiners in the germ cells we naturally anticipate that the number of boys and girls born will be equal. Curiously enough this does not seem to be quite true if our records are to be trusted. It seems that about 105 boys are born to 100 girls, the exact figures for various European countries being: England, 103.6; France, 104.6; Germany, 105.2; Spain, 108.3. If still-born infants are included the ratio is higher: Germany, 128.3; Italy, 131.1; and France, 142.2. If abortions are counted the difference appears to be even greater.[1] We do not know how to explain these returns. They do not necessarily upset our faith in the determination of sex by the chromosomes, for it may be that the cells from which males will result are more active and persistent. It may be that they are less subject to untoward circumstances. Sex ratios are very uneven in many forms of life. Bees and wasps have few males. In some species of nematode worms there is often less than one male to one hundred females and the females are really hermaphrodites. Hybrids of guinea fowl and pheasants produced 74 males to 13 females and crosses between different species of the same genus 72 males to 18 females. This inequality in the number of males and females persists throughout life, though women are often in the majority in the older age groups. Probably conditions of life and labor have much to do with these later differences, and they are not therefore sexual in origin. The following figures from the Census of the United States show this inequality:

1 Morgan, T. H. Heredity and Sex, pp. 230 ff.

*Native Whites of Native Parentage*

| | Census 1900 | | Census 1910 | |
|---|---|---|---|---|
| *Age Groups* | *Males* | *Females* | *Males* | *Females* |
| Under 10 ..... | 5,396,992 | 5,242,109 | 6,295,467 | 6,111,830 |
| 10–19 years ..... | 4,487,432 | 4,407,911 | 5,253,184 | 5,160,154 |
| 20–29 years ..... | 3,538,731 | 3,475,520 | 4,379,511 | 4,352,485 |
| 30–39 years ..... | 2,564,600 | 2,394,331 | 3,321,708 | 3,125,274 |
| 40–49 years ..... | 2,034,079 | 1,858,079 | 2,355,817 | 2,166,544 |
| 50–59 years ..... | 1,417,349 | 1,339,072 | 1,829,988 | 1,610,602 |
| 60–69 years ..... | 845,434 | 840,576 | 1,106,175 | 1,052,866 |
| 70–79 years ..... | 390,682 | 394,168 | 495,889 | 506,528 |
| 80–89 years ..... | 92,079 | 103,777 | 114,444 | 132,773 |
| 90–99 years ..... | 5,510 | 8,507 | 8,086 | 11,302 |
| 100 yrs. and over. | 129 | 264 | 180 | 259 |
| Unknown ..... | 76,830 | 35,201 | 68,769 | 28,740 |
| Total ..... | 20,849,847 | 20,099,515 | 25,229,218 | 24,259,357 |

For purposes of analysis we may conveniently divide the differences between the sexes into three groups. We may call these: (1) the primary organs of sex; (2) secondary sexual characters; (3) activities based on sex.

Among the many species of animals it is extremely difficult for us to distinguish the sexes. In countless cases the eggs are fertilized after they leave the body of the female and practically no attention is paid to the young by either parent. With each upward step on the ladder of life the relation between old and young is both longer and more intimate. No one statement of this relationship can be satisfactory for the habits of different species vary. Among birds both sexes usually share in the incubation of eggs and the care of the young, although there are some cases in which both sexes shirk this duty and leave it to other species. When the mammals are reached the connection between mother and child has become peculiarly intimate and her body shows organic differences from that of the male. The mother must shelter and nourish the unborn child and thus certain demands are made upon it which are utterly unknown to the male.

Aside from the reproductive organs there are many physical differences commonly known as secondary sexual characters. Some of these may be merely accidental accompaniments; others seem to be directly sex-linked as if certain chromosome combinations were directly responsible. In many cases it seems that the organs of reproduction actually produce substances, known as hormones, which act as stimulants to growth and directly cause the differences between the sexes. Thus male guinea pigs and rats have been castrated and female ovaries inserted. These ovaries though merely placed under the skin lived and grew. "None of these animals developed male secondary sexual characters; the male external genitalia, for instance, remained immature, and the body assumed the form of the smaller sex, the female. The growth of hair and the deposition of fat were in the direction of the female type. The mammary glands, the nipples, and their surrounding aureolae were typically female. None of these animals showed the characteristic male sexual excitability even in the presence of a female in heat. They very commonly did exhibit the 'tail-reflex' and the 'protective-reflex,' both characteristic of the female, and they were sought by the males, though of course ineffectually. Thus, so far as the secondary sexual characters were concerned, a male animal had been converted, both structurally and functionally, into a female. . . . For this reason it is believed that the hormones which are given out by the reproductive glands, and which serve to excite the development of the secondary sexual characteristics, are not the products of the germ cells proper, the egg cells and sperm cells, but come from the interstitial cells which are in no wise concerned with reproduction." [2] It seems

2 PARKER, G. H. Biology and Social Problems, pp. 52 ff.

likely that the secretion of milk in the breast is caused by some hormone and it may be that other differences between the sexes have a like explanation. Oddly enough we cannot discover that there is any such relation in the case of insects, even though the bodies of the two sexes are often unlike.

The most obvious differences in the human sexes are: (1) the larger size and greater strength of the male; (2) the different proportions of the body, particularly in the shape of the pelvis; (3) the different distribution of hair on the body; (4) the difference in the voice after maturity, resulting from the growth of the larynx.

Studies in England as well as in America indicate that from birth "until the age of nine, boys are above girls in height and weight; at nine and ten are slightly under in height; at ten slightly under in weight; at eleven materially lower in height and weight; at fourteen boys are slightly heavier than girls; at fifteen taller than girls. In other words the pubertal acceleration of growth occurs about three years earlier in girls than boys." [3] It is claimed by many students that the heads of boys are always larger than those of girls despite the superiority of the latter in weight and height during the early teens. The following table [4] shows the relative growth of schoolboys and girls at Battle Creek, Michigan:

| *Age* | | *Height* | *Degree of Difference* | *Age* | | *Weight* | *Degree of Difference* |
|---|---|---|---|---|---|---|---|
| 8 | Boys . | 124.07 | + 1.89 | 10 | Boys | 28.40 | + .27 |
| | Girls | 122.18 | | | Girls | 28.13 | |
| 9 | B ... | 128.00 | — .62 | 11 | B ... | 30.77 | — 1.22 |
| | G ... | 128.62 | | | G ... | 31.98 | |
| 10 | B ... | 131.80 | — .35 | 12 | B ... | 34.20 | — 1.52 |
| | G ... | 132.15 | | | G ... | 35.72 | |

[3] Ellis, H. Man and Woman, pp. 32–36.

[4] Hastings, W. W. In *Proceedings Conference on Race Betterment*, p. 618 ff.

| Age | | Height | Degree of Difference | Age | | Weight | Degree of Difference |
|---|---|---|---|---|---|---|---|
| 11 | B ... | 136.06 | —1.64 | 13 | B ... | 38.25 | —3.50 |
| | G ... | 137.70 | | | G ... | 41.75 | |
| 12 | B ... | 142.10 | —2.23 | 15 | B ... | 47.83 | + .33 |
| | G ... | 144.36 | | | G ... | 47.50 | |
| 13 | B ... | 146.77 | —4.53 | | | | |
| | G ... | 151.30 | | | | | |
| 14 | B ... | 153.14 | —2.26 | | | | |
| | G ... | 155.40 | | | | | |
| 15 | B ... | 158.70 | +2. | | | | |
| | G ... | 156.70 | | | | | |

The best records we have indicate that the onset of puberty causes decided changes in the rate of growth of the two sexes and causes the girls to mature more rapidly than the boys. It so happens that this corresponds with popular observation the world over.

To what extent the difference in strength as shown by muscular tests or athletic records is due to nature, to what extent to differences in daily life, in training and in ideals it is hard to determine. There seems to be no question that man is stronger. In the animal kingdom this question is in doubt, for in a few cases at least the female is larger. Manouvrier put the ratio of muscular force to body weight as 87.1 for men and 54.5 for women.

In England the average lung capacity seems to be 217 cubic inches for men, 132 for women.[5] The average height of English men is put at 67.4 inches, of women, 62.7. In America Sargent found among college men and women the following averages:

| | Height | Weight | Chest | Chest Inflated |
|---|---|---|---|---|
| Men ..... | 68 in. | 138 lbs. | 34 in. | 37 in. |
| Women .... | 63 in. | 114 lbs. | 30 in. | [6] |

A comparison of 2,300 students at Yale as compared with 1,600 women at Oberlin gave the following results:

[5] ELLIS, H. o. c., p. 230.

[6] Ibid., p. 41.

| *Strength in kilograms* | *Back* | *Legs* | *Right Forearms* |
|---|---|---|---|
| Men | 153. | 186.0 | 56.0 |
| Women | 54. | 76.5 | 21.4 [7] |

The athletic records of the University of Pennsylvania and Vassar for the year 1913 were:

| | *Penn.* | *Vassar* |
|---|---|---|
| Hundred yard dash | 9 4/5 sec. | 13 sec. |
| Running high jump | 5 ft. 8¾ in. | 4 ft. 7¼ in. |
| Running broad jump | 23 ft. 3⅞ in. | 14 ft. 6½ in. |

In man the arms and legs are relatively longer than in woman. In woman the thigh is decidedly shorter; it is set at a different angle, and is usually of larger girth than in man. The shape of the pelvis is perhaps the most striking difference between the sexes. In the balance of the animal world there is no corresponding phenomenon. The development of the large, broad pelvis of woman has been accompanied by an increase in the size of the head.[8]

"The form of woman is rounder and less variable than that of man, and art has been able to produce a more nearly ideal figure of woman than of man; at the same time, the bones of woman weigh less with reference to the body weight than the bones of man, and both these facts indicate less variation and more constitutional passivity in woman. The trunk of woman is relatively longer than that of man, and her abdomen is relatively more prominent, and is so represented in art. In these respects she resembles the child and the lower races, i.e., the less developed forms. Ranke states that the typical adult male form is characterized by a relatively shorter trunk, relatively longer arms, legs, hands and feet, and relatively to the long upper arms and thighs by still longer forearms and lower legs, and relatively to the whole upper

[7] Thomas, W. I. Sex and Society, p. 22.
[8] Ellis, H. o. c., p. 46.

extremity by a still longer lower extremity; while the typical female form approaches the infantile condition in having a relatively longer trunk, shorter arms, legs, hands and feet; relatively to the short upper arms still shorter forearms; and relatively to short thighs still shorter lower legs, and relatively to the whole short upper extremity a still shorter lower extremity — a very striking evidence of the ineptitude of woman for the expenditure of physiological energy through motor action." [9]

Among many races there is a marked growth of hair on the face of the mature man which is entirely lacking on the face of the woman, though the latter often preserves the coat of down, the lanugo, which is found early in life. Woman's hair is massed on her head and seems to be thicker and to grow longer than man's. There is reason to believe that woman is less likely to become bald.

The breaking of the boy's voice at puberty is well known. Due to the growth of the larynx the voice becomes stronger and deeper while there is little change in that of a woman. The thyroid gland, which lies just below and behind the vocal organs, is much larger and stronger in the woman.[10]

The differences in the skull are slight. The glabella, or bony projection over the nose, and the superciliary ridges are more marked in men. These overhanging brows increase with age. The frontal air sinuses are smaller in women. Some bosses on the head remain more prominent with women, but the man has thicker and stronger skull bones and the muscular prominences are more developed.[11]

It is claimed that in young infants the male brain is

[9] THOMAS, W. I. o. c., pp. 20–21.
[10] ELLIS, H. o. c., p. 266.
[11] Ibid., pp. 78–80.

already heavier, 400 grams to 380. The brain grows during childhood, reaching its maximum weight in women at about the age of 20, while in men the maximum is reached some time between 20 and 30. Thereafter it probably decreases slowly and falls rapidly in women between the ages of 50 and 60, the marked decline for men coming later between the ages of 60 and 70. From the age of 20 to 60 the male brain averages some 145 grams heavier than the female, after the age of 60 some 173 grams.[12] The following table gives the results of many studies:

| | Brain Weight In Grammes | | |
|---|---|---|---|
| *Observer* | *Men* | *Women* | *Difference* |
| Wagner | 1410 | 1262 | 148 |
| Huschke | 1424 | 1272 | 152 |
| Broca | 1365 | 1211 | 154 |
| Topinard | 1360 | 1250 | 110 |
| Bischoff | 1362 | 1219 | 143 |
| Boyd | 1354 | 1221 | 133 |
| Manouvrier | 1353 | 1225 | 128 |
| Total average | 1376 | 1237 | 139 [13] |

Trouble comes when we attempt to interpret these results. Man's height in comparison with woman's may be stated as 100 to 93. On this basis the brain weights are as 100 to 90 and man's brain appears to be relatively heavier. If, however, we take the body weight as the basis the results are reversed. Man's body weight as compared to that of woman may be put as 100 to 83; the brain weight remaining, of course, 100 to 90. Moreover the brain weight is relatively fixed while the body fluctuates, and in addition women have more fat. If we try to eliminate this and compare on the basis of active organic tissues we should have to put the ratio as 100 to 70 and

[12] Moebius, P. J. Ueber den physiologischen Schwachsinn des Weibes, pp. 1–39.

[13] Ellis, H. o. c., 103.

woman's relative superiority in brain weight would be more pronounced.

We are really ignorant of any relationship between weight of brain and mental capacity, hence, all deductions based on brain weight are of doubtful value. Two insane women, one with a brain of 1,742 gr., the other of 1,587 gr., are reported and these weights, be it noticed, are far above the average for normal men; while one male idiot is said to have had a brain weighing 2,850 gr. There seems to be no justification in the present state of knowledge for assuming that either sex has any advantage so far as mental ability is concerned. Even Broca, the French anthropologist, who in early life thought that man was superior in this regard, later came to think that it was a question of education.[14]

Apparently one of the most significant differences yet discovered is in the specific gravity of the composition of the blood. All observers seem to agree that the blood of woman contains fewer red corpuscles, while the specific gravity is lower.

"In males the specific gravity is about 1,066 at birth, and falls during the subsequent two years, being about 1,050 in the third year; thence it rises till about seventeen years of age, when it is about 1,058. It remains at this height during middle life, and falls slightly in old age.

"In females the specific gravity, starting at about 1,066 at birth, falls in infancy, as in males, to about 1,049 in the third year. Thence it rises till the fourteenth year, when it is about 1,055.5. Between seventeen and forty-five years of age it is lower than at the age of fourteen, and is about three degrees lower than in men.

[14] Ellis, H. o. c., p. 123.

"It will thus be seen that it is at puberty that the sexual difference becomes marked. . . . In old women the specific gravity rises." [15]

"Men produce more carbonic acid than women. According to Andral and Gavarret, the amount of carbon burnt per hour is, from eight to fifteen years of age, in the boy 7 gr. 8, in the girl 6 gr. 4; from sixteen to thirty, in the man 11 gr. 2, in the woman 6 gr. 4; that is to say, the amount consumed in man rises at puberty to nearly double that consumed in woman." [16] As a result women seem to need less air than men.

There is reason to believe that women stand surgical operations better than men. The following table seems to indicate a difference of 9.27 per cent in favor of women:

| | *Amputations* | *Deaths* | *Deaths per 100* |
|---|---|---|---|
| Men ..... | 1,144 | 441 | 38.56 |
| Women ..... | 284 | 83 | 29.29 [17] |

"Statistics show that woman is more susceptible to many diseases, but in less danger than man when attacked, because of her anabolic surplus, and also that the greatest mortality in woman is during the period of reproduction, when the specific gravity of the blood is low and her anabolic surplus small." [18]

When one considers the hosts of facts, of which those cited are but a few from different fields of evidence, it is no wonder that the idea is prevalent that woman is essentially anabolic, i.e., tends to store up strength and energy, while man is katabolic, i.e., tends to spend and dissipate his energy. The biologist would say that this is a pro-

[15] Ellis, H. o. c., p. 225.
[16] Ibid., p. 230.
[17] Thomas, W. I. o. c., p. 17.
[18] Ibid., p. 42.

vision of nature to enable woman to meet the great strain which the bearing and nursing of children puts upon her. A further indication of this is given in the relative percentages of fat and muscle. Below are recorded the figures for a woman, a man, and a boy, all of whom died accidentally and in good physical condition: [19]

| | *Man* | *Woman* | *Boy* |
|---|---|---|---|
| Muscle ..... | 41.18 | 35.8 | 44.2 |
| Fat ..... | 18.2 | 28.2 | 13.9 |

It is no wonder that Ploss, after reviewing the evidence, concluded: "The bodily needs of women are much less than those of men; they eat and drink less; they breathe less and withstand suffocation better, it is believed. All troubles, at least those which slowly develop and persist, all deprivations, they bear much better than men; in part at least, much better than one would expect in consideration of their physical powers. They better withstand loss of blood and persistent pains. Even the greater sensitiveness of the nervous system, because of which many trifling disturbances cause lasting after effects, appears to favor the rapid and harmless dissipation of the upsetting experiences. Thus they reach old age, often, under unfavorable circumstances, though the cases of extreme old age reaching well into the second century are almost always men." [20]

Girls as indicated reach physical maturity at a somewhat earlier period than boys. In the tropics the age at time of first menstruation ranges from 8 to 19, the maximum being reached at 12; while in cold countries it ranges from 10 to 22, reaching the maximum at 16. The oncoming of menstruation marks a tremendous change in the life of the female and introduces a function which has

[19] Thomas, W. I. o. c., p. 30.
[20] Ploss, H. Das Weib, p. 38.

no counterpart in the male. We have noted the rhythms of life in other connections. Menstruation is one of the most significant rhythms to be found among women. It is important not merely because of its assumed relation to reproduction but because of its pronounced influence on the physical and mental condition of the individual. "While a man may be said, at all events relatively, to live on a plane, a woman always lives on the upward or downward slope of a curve. . . . It is at this time, in those women who are at all predisposed, that sudden caprices, fits of ill-temper, moods of depression, impulses of jealousy, outbursts of self-confession, are chiefly liable to occur. . . . On the mental side the irritability or depression may be so pronounced as to amount to insanity. Migraine is a common disorder at this period. Erotomania, dipsomania and kleptomania are also specially liable to be developed at this time, and of all forms of insanity melancholia is the most liable to occur. Whenever a woman commits a deed of criminal violence it is extremely probable that she is at her monthly period; it is unfortunately difficult to give precise figures as there is often neglect to ascertain this point. Lombroso, however, found that out of 80 women arrested for opposition to the police, or for assault, only 9 were not at the menstrual period. . . . Krugelstein stated that in all cases (10) of suicide in women he had met with, the act was committed during this period. . . . Women in prison, again, are apt to exhibit periodic outbreaks of unmotived and apparently uncontrollable violence: these . . . are especially liable to occur at the menstrual epoch. . . . Among the insane, finally, the fact is universally recognised that during the monthly period the insane impulse becomes more marked, if, indeed, it may not appear only

at that period. . . . In the investigation of any fact in a woman's life or organism, we ought to know its exact position in the woman's cycle life. . . . The existence of the monthly cyclic is, lastly, a factor which cannot be ignored in considering the fitness of women for any business position. . . . One point at all events is clear: it is no longer possible to regard the physiological periodicity of women, and the recurring menstrual function, as the purely private concern of the woman whom it affects." [21]

On this question the opinion of those competent to testify is practically unanimous. It has been attacked recently by a woman, Mrs. L. S. Hollingworth, in her volume entitled "Functional Periodicity." This is a monograph based on only 23 cases, but 6 of which were intensively studied. She was able to discover no marked change in mental or motor reactions during menstruation. She states her own attitude in positive fashion, more positive it would seem than is warranted by the facts.

"From whatever source or sources the idea of woman's periodic irresponsibility may have risen, it is certainly very widespread. . . . Yet the irresponsibility and inefficiency so widely proclaimed in theory are not considered and are not realized in practice. The psychologist writes that there are grave and profound changes in mind and body during menstruation; yet he makes no allowance for this in his experiments on women subjects. The physician declared fifty years ago that women were forever unfitted for higher education because of this function; yet the number of women graduated from colleges and universities in perfectly normal health increases yearly. It is positively asserted that women cannot successfully pursue professional and industrial life because they are

[21] ELLIS, H. o. c., pp. 284–298.

incapacitated, and should rest for one-fifth of their time; yet it is not proposed that mothers, housekeepers, cooks, scrub-women and dancers should be relieved periodically from their labors and responsibilities." [22]

Through all the ages it has been believed that the phenomena of magic, hypnotism, mesmerism, or whatever they may be called, have appeared chiefly among women. Experts have claimed that two-thirds of the hysterical women could be hypnotized and only one-fifth of the hysterical men. Women are alleged to dream more than men. They are also more excitable under anesthetics. Such phenomena have led to the idea that women are more emotional than men; that is their feelings are less under the control of the higher brain centers. "Pitres and Régis found that it is at puberty, between 11 and 15 years of age, that obsessions most usually begin to take root in the mind, and that it is between 26 and 30 (also a somewhat critical age in women) that they most usually develop. It is the same suggestibility that causes women to be less subject to nostalgia, or home-sickness, than men, and more adaptable to changes of habit and new impressions." [23]

Again it is hard to determine whether the differences seen are due to actual differences of constitution or to social and mental habits. The daily life of the two sexes, even in the emotional and intellectual sphere, is so different in our modern civilizations; the traditions of the proper sphere of activity for the two are so divergent, that we must expect different reactions. If, as now seems likely, women are to enter upon most if not all of the callings hitherto reserved for men, it is very probable that this

[22] Hollingsworth, L. H. Functional Periodicity, p. 97.
[23] Ellis, H. o. c., p. 353.

difference in emotionality will be reduced. Additional mental training given to woman and larger contact with the world will tend to subdue emotionalism and to strengthen rational processes. Men are less emotional today than were primitive men. We must not therefore exaggerate the physical differences, nor make the equally foolish mistake of ignoring them.

"As such social changes tend more and more to abolish artificial sexual differences, thus acting inversely to the well-marked tendency observed in passing from the lower to the higher races, we are brought face to face with the consideration of those differences which are not artificial, and which no equalization of social conditions can entirely remove, the natural characters and predispositions which will always inevitably influence the sexual allotment of human activities. So long as women are unlike in the primary sexual characters and in reproductive function they can never be absolutely alike even in the highest psychic processes." [24]

It has been hinted that there is an attempt to explain these differences on the ground that woman represents the older and less variable type of structure, while man is rather the testing field of nature's experiments, and therefore much more variable. Albrecht offers the following evidence to justify such a conclusion:

"Many facts show that the female of the species is the more persistent, that is, stands nearer to our wild ancestors. Such facts are:

1. The shorter stature
2. The more frequent occurrence of a high degree of long-headedness
3. The more frequent and greater prognathism

[24] Ellis, H. o. c., p. 17.

4. The greater development of the middle incisors
5. The marked development of the third trochanter
6. The less frequent union of the first vertebra of the coccyx with the first vertebra of the sacrum
7. The more frequent appearance of five vertebrae in the coccyx
8. The more frequent development of hypotrichosis
9. The less frequent baldness

"As regards the third trochanter, it is to be noted that while this appears in the human female, it is seldom found in man and even more rarely in the apes. It is especially interesting that in this regard the human female sex shows itself as more persistent than the mass of the apes, and that it harks back to a race that in any case was wilder than the present world of apes. That the human female, moreover, is not only anatomically but also physiologically the wilder sex is revealed by the fact that men very seldom bite or scratch their opponents while nails and teeth ever remain the preferred weapons of the female." [25]

In more restrained language Thomas concludes: "It must be confessed that the testimony of anthropologists on the difference of variability of men and women is to be accepted with great caution. As a class they have gone on the assumption that woman is an inferior creation, and have almost totally neglected to distinguish between the congenital characters of woman and those acquired as the result of a totally different relation to society on the part of women and men. They have also failed to appreciate the fact that differences from man are not necessarily points of inferiority, but adaptations to different and specialized modes of functioning. But, whatever the final interpretation of details, I think the evidence is sufficient

[25] Ploss, quoted by, o. c., p. 6.

to establish the following main propositions: Man consumes energy more rapidly; woman is more conservative of it. The structural variability of man is mainly toward motion; woman's variational tendency is not toward motion, but toward reproduction. Man is fitted for feats of strength and bursts of energy; woman has more stability and endurance. While woman remains nearer to the infantile type, man approaches more to the senile. The extreme variational tendency of man expresses itself in a larger percentage of genius, insanity and idiocy; woman remains more nearly normal." [26]

It would seem then that the differences between men and women are the differences due to sex. It is foolish to talk about the inferiority or superiority. They are different. That is all. In this connection we must remember that sex is not inherited from one parent any more than from the other. The sire has as much to do with the quantity and quality of the milk given by the cow as does the dam. We must not forget that the chromosomes in each cell of the body come from both parents, not from one alone. It is impossible then at the present to be sure that we understand the full significance of sex differences. It is evident that many of the divisions of labor and customs have been based upon artificial or, at least, insignificant reasons.

We are not particularly concerned here with the rôles men and women are playing in present life or the theories as to the parts they should play. There seem to be two prevalent philosophies as to the activities. The first is held by most men and by many women may be summed up in words attributed to Martin Luther: "If a woman becomes weary, or at last dead from bearing, that matters

[26] THOMAS, W. I. o. c., pp. 50–51.

not; let her only die from bearing. She is there to do it." Some advocate the restriction of woman's activities to the care of children and flesh-pots on purely sentimental grounds; others, because they can conceive of no higher or more important service. The second view, earnestly advocated by an increasing number, is that woman must pass from the condition of status to one of contract. She must decide for herself what she is to do, and should have the right to motherhood or not as she pleases. Whether this attitude carries a covert threat to the future of the race and society is solely a matter of opinion. Personally I see no reason to fear for the permanency of the race. What woman will do she must decide, and what she will decide, no man knows.

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## CHAPTER IX

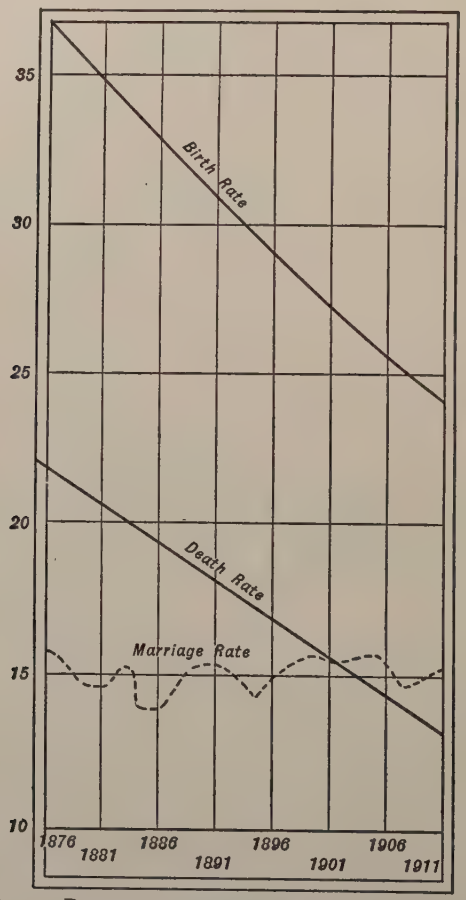
## THE INFLUENCES OF SOCIETY UPON POPULATION

The evidence thus far offered indicates that while we are not to consider the human body as perfect, we are justified in the assumption that the overwhelming majority of children are born sound and normal in body and mind. It is equally clear that all children are not born into the same world, that for some every care has been taken in advance and everything which knowledge can suggest or money furnish will be provided, while for others neglect begins even before birth. Social facts thus play a large part in the actual life of the child, and, as will be shown, influence in no small way the number of children born.

A century ago Malthus, speculating on the actual and possible increase of the human race, made his famous generalization that while food supply tended to increase in an arithmetical ratio, population tended to increase in a geometrical ratio. Could Malthus visit earth today he would doubtless be surprised to find that during the century there has been a steady increase of the population of Europe and America, that the birth-rate has steadily fallen, the death-rate as well. Would he also conclude that some checks had been deliberately applied? In Europe the increase was from 175 millions in 1800 to 420 millions in 1900.

First, then, what are the facts? The following diagram will illustrate the change which has taken place in England and Wales. It will be seen that while the birth-

rate and the death-rate have steadily fallen the marriage rate has remained fairly constant.




BIRTH, DEATH AND MARRIAGE RATES, ENGLAND AND WALES, 1876–1911

The English birth-rate in 1861 was 34.5, death-rate 21.5, infantile mortality 15 per cent, an excess of 13 births over deaths per 1,000, or 1,000 became 1,013 each

year. The birth-rate rose to 36 in 1876. In 1900 it was 25 and is now lower. The death-rate has fallen to about 14 and the infantile mortality rate is about 10 per cent. The population is increasing almost as fast as before fall of birth-rate.

The German birth-rate rose to 41 in 1876, and has since fallen to 31. The death-rate has declined from 29 to 17, and the infantile mortality rate from 21 per cent to 17 per cent.

In France the birth-rate in 1881–84 was 38.9, falling in 1901–96 to 21.1, but the death-rate in the same time fell from 37 to 19.6, so rate of increase is about the same.

Holland had a birth-rate in 1876 of 37 which has fallen to 29 but the death-rate has fallen from about 25 to 13 and infantile mortality from 18 per cent to less than 10 per cent. Since 1895 Holland has taught by royal decree methods of preventing conception. According to the official year book the proportion of men drawn from the army over 5 feet 7 inches has increased from 24.5 per cent to 47.5 per cent since 1865 and the proportion under 5 feet 2½ inches has fallen from 25 per cent to less than 8 per cent.

The Australian birth-rate fell from over 42 in 1860 to a little over 26 in 1910. The death-rate fell, however, from average of about 18 to a trifle over 10 and infantile mortality from 11 per cent to about 7 per cent.

The New Zealand birth-rate in 1855 was about 42; in 1910, about 26. The fertility rate has steadily declined from 337.2 per 1,000 married women in 1878 to 226.6 in 1906. But the death-rate has fallen likewise from about 17 in 1860 to a little over 9 in 1910, and the infantile mortality rate is now about 7 per cent. The result is that excess of births over deaths is about 16 per thousand,

enabling the population to double in 44 years and increase 4.8 fold in a century.

Canada showed a decrease in birth-rate up to 1895 since when it has increased but curiously the death-rate showed a similar change.

The British Registrar-General reports on 29 countries. In 18 the birth-rate has fallen but the death-rate has likewise fallen in practically equal proportion. In 4 the birth-rate is stationary (Russia, Roumania, Jamaica and Ireland). In these the death-rates and infantile mortality are also stationary. Russia with a birth-rate of 50 has highest death-rate of Europe, 36, and highest infant mortality rate 26 per cent.

In 4 the birth-rate has risen (Bulgaria, Ceylon, Japan, Ontario). In each the infant mortality and death-rates have risen.[1]

These figures have attracted much attention, particularly in Europe, where their significance is widely discussed; most of all perhaps in France, where the population has become almost stationary. In analyzing the situation it becomes clear that this decline varies with the economic status of the different groups. The accompany-

*Birth Rate in France*[2]

| *Departments* | *Personal property tax and tax on doors and windows* | *Legitimate births per 1000 marriageable women* |
|---|---|---|
| 10 | .75 — 1.21 fr. | 23.63 |
| 9 | 1.29 — 1.41 | 21.88 |
| 11 | 1.46 — 1.59 | 18.06 |
| 8 | 1.65 — 1.73 | 16.66 |
| 9 | 1.80 — 1.93 | 15.84 |
| 10 | 1.98 — 2.06 | 16.33 |
| 10 | 2.13 — 2.42 | 15.94 |
| 9 | 2.52 — 2.82 | 17.77 |
| 10 | 2.98 — 4.34 | 14.73 |
| 1 | 6.73 | 13.24 |

[1] DRYSDALE, C. V. The Small Family System, p. 51 ff.

[2] SCHALLMAYER. Vererbung und Auslese beim Menschen, p. 125.

ing table shows this. The reader is warned not to assume that the difference of a few francs in taxes paid is the cause of the phonomenon.

Leroy-Beaulieu adds that in France in the better situated groups the birth-rate is relatively low and is much higher in the poorer groups. In Paris the Chief of the Statistical Bureau states that 34–52 children are born yearly to each thousand women (aged 15–50) of the richer classes while 95–108 children are born to each thousand women of the poor groups.

As further evidence, we may add a diagram [3] based on the returns from a number of European cities:

*Birth Rate according to Degree of Wealth in Different Sections of European Cities*

AVERAGE NUMBER OF ANNUAL BIRTHS PER 1000 WOMEN FROM 15 TO 50 YEARS OF AGE

| | No. yrs. | *Very poor* | *Poor* | *Well off* | *Very well off* | *Rich* | *Very rich* |
|---|---|---|---|---|---|---|---|
| Paris ..... | 5 | 108 | 95 | 72 | 65 | 53 | 34 |
| London ..... | 9 | 147 | 140 | 107 | 107 | 87 | 63 |
| Berlin ..... | 9 | 157 | 129 | 114 | 96 | 63 | 47 |
| Vienna ..... | 5? | 200 | 164 | 155 | 153 | 107 | 71 |

There is a very widespread belief that this is true in the United States also and there is much evidence thereof in spite of the deplorable condition of our vital statistics. The following figures are to the point:

Kuczynski estimates the births in the native population of Massachusetts at 63 to each 1,000 women of child-bearing years. The French figure is about 85, English, 104; Russian, 143. If French population is stationary, New England must be actually losing.[4]

[3] BERTILLON, J. Quoted by Chatterton-Hill — Heredity and Selection in Sociology, p. 325.

[4] KUCZYNSKI, R. *Quarterly Journal of Economics.* Nov., 1901, and Feb., 1902.

Based on census figures it has been shown that in certain selected districts 13.1 per cent of the native white women who had been married from 10 to 20 years had borne no children, while only 5.7 per cent of the women of foreign parentage were childless. One woman in eight of the native stock was childless, as compared to one in twenty of the foreign. Of the second generation in America, 6.3 of the women had no children. The white natives had borne a child every 5.3 years, foreign whites every 3.2 years. Women of English parentage had a child every 4.2 years, those of Polish parentage every 2.3 years. City communities show highest percentage of those having no children. The average number of years married per child born was 3.8 in Rhode Island; 3.5 in Cleveland; 3.6 in rural Ohio; 4 in Minneapolis and 2.8 in rural Minnesota. While these figures may not apply to the United States at large, they indicate certain real differences and changes of great meaning.[5]

"I recently examined 150 Irish families in northern Pennsylvania, who are now in the second American generation. These families were of the best classes that emigrated about the time of the famine of 1847. With two exceptions (where the fathers became drunkards here) they gave the children the best example; they all succeeded financially so that their children were well fed, well housed and educated: nearly every family was able to send some of its sons to college. In the first American generation there were 5.52 children as the average to each family. If there were a full progression at this rate, these fifty families should now be represented by 1,523 persons. The total, however, in the second generation will not reach

[5] Hill, J. A. In *Quarterly Publications of American Statistical Society*, Dec., 1913, pp. 583–604.

200 persons and I am practically certain there was no prevention of conception.

"In the first American generation there were 276 children, 149 males, 127 females. Of these 53 men, over 35 per cent were chronic alcoholics, public drunkards; 6 of the women also were public drunkards. Twelve of the men and four of the women became insane." [6]

Though it seems impossible in the present state of knowledge to explain this phenomenon adequately, much less assign relative values to the different forces at work, we can discover some of the causes, and we may divide these into indirect and direct.

1. The increased length of infancy as civilization advances, already mentioned, automatically defers the age of marriage. This affects the number of children adversely. Galton said that the children of a man marrying at 20 as compared with those of a man marrying at 28 is 8 to 5. Rubin and Westergaard made the following estimates: [7]

| *Age of man at marriage* | *Number of Children* |
|---|---|
| Under 25 | 3.50 |
| 25 — 29 | 3.25 |
| 35 — 44 | 2.28 |
| Over 45 | 1.10 |
| 30 — 34 | 3.02 |

These statements are based on supposedly reliable evidence but it seems to me that they are inadequate. The sexual life of the man is much longer than that of the woman. If it can be shown that her marriage is deferred, the conclusions would be more valuable. On this question, reliable evidence is lacking. We have assumed that in early New England the women married very young, but

[6] A. O'MALLEY. The Cure of Alcoholism, p. 97.

[7] Schallmayer, quoted by, o. c., p. 132.

this has lately been questioned. The smaller number of children when the fathers marry late may be due to other causes. It seems true that the women of the so-called upper groups marry later than those of the working classes, so there is doubtless some real influence exerted. Civilized women certainly marry later than those in more primitive societies.

2. Child-bearing appears to be more difficult for civilized woman than for her ancestors and harder for the women in the upper classes. Certain it is, whatever the cause, that instrumental delivery has become increasingly common in the last century. Medical skill saves a good many lives today which would have been sacrificed a generation or two ago. In earlier years, the woman would have died, the man would probably have remarried and had more children. Now the family is preserved, but the number of children is decreased. The records of old New England families strikingly confirm this inference.

3. Celibacy, however caused, plays an important part in so far as the groups affected are concerned. The withdrawal of so many of the best men and women into the priesthood or the nunneries, the growth of prostitution with its sterility-producing diseases, compulsory military service extending over years at just the period when men ordinarily think of marriage, world-wide commerce which may develop the roving spirit at the expense of the desire for individual homes, all play their part.

4. What we may term selfish ideals growing out of a desire for an easier life for either parents or children have bad as well as good influence. On the one hand, they may lead to better care and training of fewer children; on the other, to a disinclination to work and compete with others for the rewards of life. Either affects the rate of

reproduction. We may say without exaggeration that large families are no longer in style.

5. Immigration is held by many to be an important factor particularly in America. A generation or more ago, Walker and others argued that the population of the country would be as large as it is today had there been no immigration on the assumption that the colonial birth-rate would have remained had it not been for the incomers with whom the older groups did not care to compete. This assumption seems very doubtful. England with no immigration for centuries until the recent advent of the Russian-Jew and with a great loss through emigration has shown a marked decline in birth-rate, while France with no immigration has actually lost in aggregate population. Underlying Walker's idea was also the assumption, which we need not discuss, that the older stock was better than the newer.

6. Religious beliefs and institutions have great influence. The Jewish emphasis on large families, the desire of the Chinese to maintain ancestor worship, the Mormon emphasis on the duty of incorporating as many as possible of the unborn spirits, all tend to keep up the birth-rate. That religious leaders are less insistent than formerly on this question is not to be doubted.

7. Increasing divorce doubtless has some influence, but just what or how much it is hard to say. In spite of divorce a larger percentage of the population appears to be living in marital relations than formerly. If this is true, it is easy to overemphasize the importance of divorce.

8. Diseases and accidents, most of which are preventable, are also to be considered. The lowering of the standard of living affects the desirability of children quite as directly as does the accidental death of one parent. The

elimination of needless suffering and loss would tend to increase the birth-rate.

9. More important than many of the foregoing would appear to be the changed industrial conditions, particularly the opening of new avenues of employment to women. This makes them more independent, more judicious in their choice of life partners, and tends, therefore, to later marriage as well as to celibacy. This is accentuated by such stupid decisions as the refusal to employ married women as teachers, or by their discharge if they become mothers.

So far the causes considered have worked indirectly in the main. There are others, however, of more immediate effect.

1. Disease plays a rôle often underestimated. Gonorrhea alone is held by physicians responsible for one-half of the involuntarily childless marriages. When both parents are syphilitic at time of conception no child, probably, is born alive. Even where one only is a victim of this disease, the results are terrific. A Chicago physician saw 1,700 cases of syphilitic mothers. Five hundred and seventy-eight or 34 per cent resulted in miscarriages or still births. Nine hundred and fifty-six living children were born who died within 12 months after birth, a combined total of 1,534 of the 1,700 or 90 per cent who did not reach the age of one year. A large part of the remainder were crippled by the disease. Other diseases probably have considerable influence on child-bearing.

2. Vice, like alcoholism, particularly on the part of pregnant women, decidedly affects the unborn child and the mother's ability to nurse it.

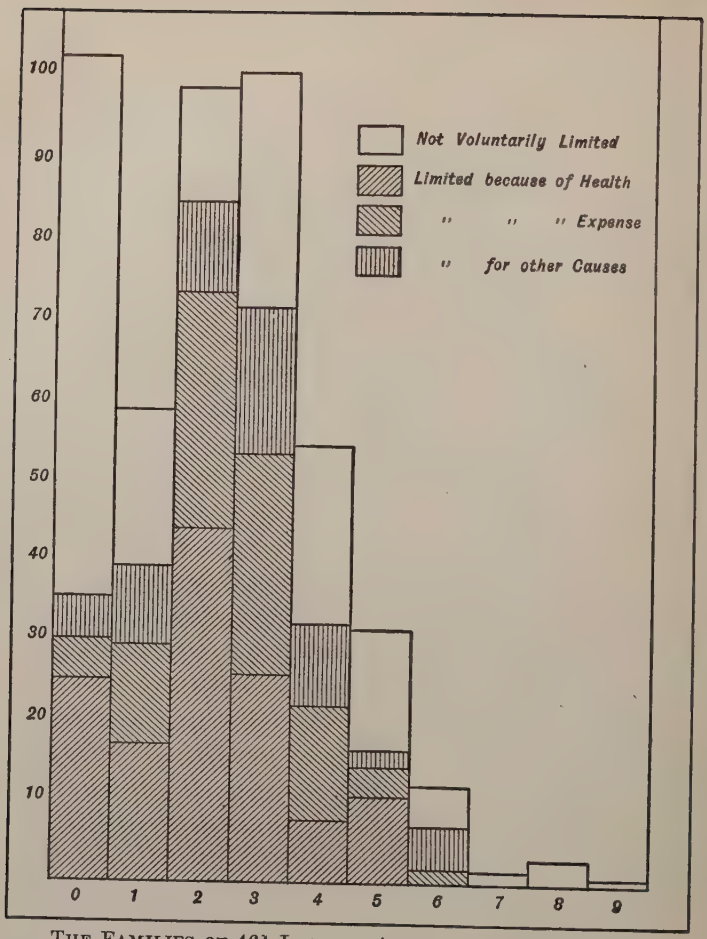
3. Abortion, though prohibited by law, still exists and

there is probably no large town or city where some one will not perform it if the financial inducement is large enough.

4. By common consent the most important factor in limiting the birth-rate is the prevention of conception either by the exercise of self-control or by direct contraceptive measures. In the educated groups of all Western civilizations this is seemingly almost universal. The evidence for it is not to be reduced to statistical tables unless one is willing to accept the different birth-rates of the different economic levels of the same race stock as satisfactory. Society is by no means agreed as to the righteousness of the practice nor is its attitude on the subject wholly free from hypocrisy. Direct teaching and the sale of publications or contraceptive instruments are usually prohibited. Holland, however, has for some years openly taught the poorer classes how to prevent conception and with good results, so it is claimed. In all countries there are those who believe in small families rather than large and who argue that it is foolish to permit ignorance to be responsible for the birth of large numbers of children for whom the parents cannot provide proper care and training. Others advocate large families even if society at large must assume parental responsibility.

5. It has been suggested that the conditions of life of the upper classes called for such nervous expenditure in many directions that the physical strength was sapped and reproduction automatically checked. For this there seems to be little direct evidence.

The most interesting diagram that I have seen in this field is that by Dr. J. McKeen Cattell, published in the New York *Independent* which is here reproduced.




THE FAMILIES OF 461 LEADING AMERICAN SCIENTIFIC MEN

The figures at the bottom indicate the number of children to a family; those at the left the number of families of equal size. The chart shows for each size of family of 461 American men of science in how many cases the limitation was involuntary and in how many cases it was voluntary. The shaded areas, showing the number in which it was voluntary, are subdivided to indicate the causes. Thus, when the marriage was childless, this condition was involuntary in 67 cases and voluntary in 35 cases. The reasons assigned were health in 25 cases, expense in 5 cases and other causes in 5 cases. In the family of two, the limitation was voluntary in 84 out of 98 marriages. The reasons assigned were health in 44 cases, expense in 29 cases and inconvenience or other causes in 11 cases.[7]

[7] CATTELL, J. MCKEEN. *Independent*, September 27, 1915.

It seems to me that the conflict of ideals is not as divergent as extremists on either side believe. All are agreed that we want the race maintained and that we want the children well trained, equipped with sound minds and bodies. If society will undertake the task large families may be desirable even for the poor. I assume that the unfit will be eliminated. If society is not ready to assume such a burden we have the option of continuing the present policy with its enormous burden of misery and neglect, or the attempt to reduce it by the limiting of the family.

Entirely aside from the question of reproduction there are many ways in which, it is claimed, society interferes with natural evolution. These must be considered. The interference with natural selection is specially stressed and the following claims are made:

1. It is alleged that human ingenuity has stopped man's physical evolution. Thus Drummond argued that there was no reason to anticipate further development of the hand because man's invention of tools had removed the necessity for better hands. In like fashion he claimed that the use of glasses had stopped the advance of the eyes, indeed he thought a marked retrogression could be seen because now man could make cameras, telescopes, miscroscopes, etc., which were better than natural eyes. Smell and hearing were also tending to disappear he believed.[8]

2. Surgical skill and medical knowledge by preserving the relatively unfit, that is the naturally poorer types, have stopped the struggle for existence and this is held to be very unfortunate. In part this argument may be considered as a corollary to the preceding paragraph, in part

8 DRUMMOND, HENRY. Ascent of Man, Chap. III.

it covers new ground. The use of glasses, for illustration, makes it possible for many to remain in the ranks of teachers who would otherwise be forced into professions calling for less use of the eyes. But success in teaching turns upon many things besides eyes, and whether the exclusion of those with relatively poorer eyes would be socially advantageous or not, is not easily answered. A bit later we will consider the physical side of the problem. The preservation of the lives of types of women not fitted to become mothers has been mentioned already. In like fashion the cutting down of the death-rate from smallpox, malaria, typhoid, tuberculosis and yellow fever may be held to be unwise for it preserves the types susceptible to these diseases whereas the older conditions would have ultimately destroyed the susceptible types and the survivors would be free from their attacks. Again this entirely disregards the question of the social fitness of the susceptible individuals.

3. The attempt to prevent the formation of vicious habits by the prohibition of the sale of the agents used has been considered ill-advised. Thus G. A. Reid in "Alcoholism," an extreme but thought-provoking work, asserts that the older races of earth have, through long contact with alcohol, weeded out the types liable to alcoholism, and today need no artificial protection against it. The newer races, only recently possessed of alcohol in large quantities, are those that yield to its seductive influence to any degree. Therefore, says Reid, the Jews are practically free from alcoholism, while the Irish are often its slaves. The thing to do then, is to permit those who want to drink themselves to death to do so, and the sooner the better. We shall then have a race no longer in danger and thus in the long run will be better off. The warfare

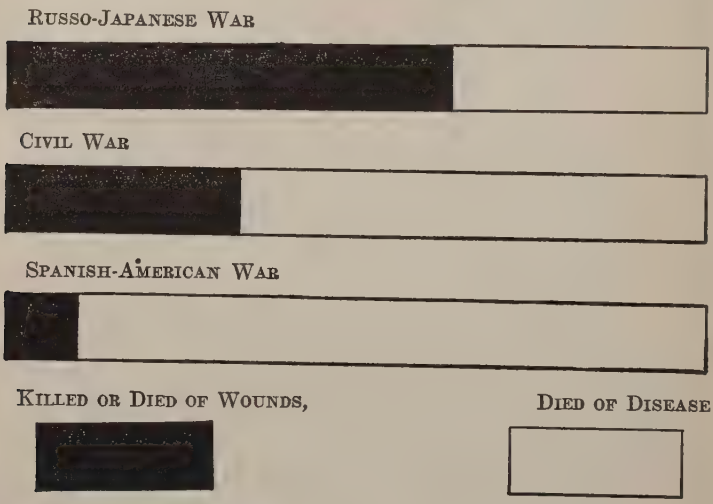
against alcohol, opium, peyote, coca-cola, hasheesh, tobacco, chloral, or whatnot is all wrong, say the advocates of what has been picturesquely called the "open-door-to-hell" policy, but nowhere has this policy found a large following in modern communities.[9]

4. War, as formerly conducted, that is as a direct struggle between individuals, has often been defended as a selective agency in that the weaker were destroyed. Modern warfare has become a contest of machines and destroys the strong as well as the weak. Solid shot and shrapnel make no distinction of persons. The diseases which have accompanied the wars of the nineteenth century have been far more deadly than the bullets and have in measure perhaps reintroduced the selective factor. But human skill will soon eliminate most of the incidental diseases. The contrast between a war conducted with due regard for modern science as by the Japanese, and one in which medical science was neglected (the Spanish-American War) or one antedating modern medicine (Civil War) is most striking as the following diagram reveals. It shows percentages of killed or dying from wounds; and from disease.

Opponents of all warfare point out that the terrific loss of life from whatever cause remove from the ranks of society, and of parents great numbers of young men in the prime of life who are the cream of the population from the physical standpoint because they have passed strict examinations which the weaklings cannot survive. They argue that Napoleon's campaigns reduced the average stature of the French and introduced a lot of degeneracy. The evidence on this point has seemed a bit less conclusive since August 1, 1914.

[9] Reid, G. A. Alcoholism, p. 97–112.

5. It is claimed that religious fanaticism leading to the destruction of many of the best men and women of the country, as in Spain during the Inquisition, has done incalculable harm to the people by changing the relative percentages of the higher and lower groups in the popula-




The Causes of Death in Three Wars

tion, and no one can doubt a certain justification for the claim. Just as the world had thought that such wholesale martyrdom was a thing of the past comes the biggest thing of the sort on record in the practical annihilation of the Armenians by the Turks in 1915.

6. Modern humanitarian movements, the emphasis on the sacredness of life, the attempt to reform criminals, the care of the poor and afflicted, are often charged with being decidedly anti-social in their results. Why save the unfit? Why not let them perish and thus avoid not only the expense of caring for them but also avoid the taint they pass on to later generations?

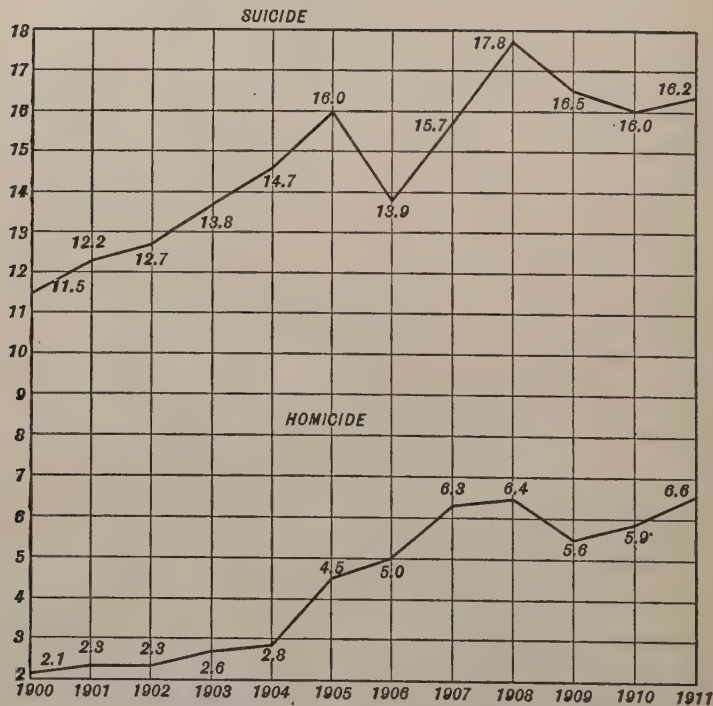
7. The development of social castes, particularly when membership becomes a matter of birth-right, works harm in two ways. First, it checks and nullifies ambition on the part of gifted members of the lower groups. Second, it maintains in positions of power and responsibility those who are often unfit. The opponents of this argument maintain that in the long run the able members of the lower groups are taken into the higher and thus no real harm is done. As proof they cite the fact that the nobles in all countries are short lived. Thus, De Chateauneuf claims that in France such families seldom last over ten generations, or 300 years. Among 280 houses he found only 20 which pass the title uninterruptedly 9 or 10 times to the first born. Among the Nobles of the Robe the average family life was 230 years. The same general situation is true also of England and Germany.[10]

8. That modern industry is accompanied by an enormous number of accidents is true. That it has produced new types of diseases due to the poisonous nature of substances used such as lead and sulphur, that work such as tunneling under rivers has given us the "caisson disease" is true. That sudden changes of temperature resulting from work in iron furnaces and the exposure to outer air has furnished favorable soil for tuberculosis and pneumonia admits of no doubt. It is alleged further that progressive degeneration of the working class is going on. As proof we are reminded that the English have had to lessen the army entrance requirements several times in the last century; that recruiting stations in the industrial districts of Pennsylvania at the time of the Spanish war were closed because the applicants could not pass the tests. These are unquestioned facts. If the inference is

10 Reibmayr, A. Inzucht und Vermischung, pp. 261 ff.

also true, our civilization is threatened with a slow process of suicide.

9. Much weight is also laid upon the increase in all civilized lands of suicide. Here the evidence is striking. In 13 European states, there was an increase from 104 per million in 1868 to 134 per million in 1882.




Increase in Suicide and Homicide in Registration Area of U. S. Rate per 100,000 of Population

Mention has already been made of a real or apparent increase in the number of the insane and the claim has been made that this amounts to 100 per cent per decade. In the state of Michigan in the years 1890–91 for each

10,000 of the population there were 17.44 treated in the State Hospitals; in 1900–01, 20.63; in 1914–15, 30.19; the actual number treated having increased from 3,652 to 8,955. In Europe similar claims are made. In spite of the fact that the English commission reported a decided increase in the number of the feeble-minded, and the prevalent belief that the same holds true here, there is room for doubt. We recognize and treat many cases of mental defect and disease that would have passed unnoticed a generation ago and our institutional provision is so much better that we probably treat a larger percentage of those needing treatment. If it could be shown that present conditions of life and labor were causing the mental breakdown of the people the outlook would be more serious. We know that much of insanity is the result of vice, alcoholism, worry and disease, and these are not necessarily the accompaniments of civilization.

10. More and more thoughtful students are coming to realize that the institution of private property with the right of the inheritance thereof is profoundly affecting our whole life. With the disappearance of free land our social system is being changed. With the concentration of wealth in a few hands the opportunities of the propertyless are radically modified. It has been claimed that the richest one per cent of the people receive a larger income than the poorest fifty per cent. It is argued that this is changing the race stock.

We have now surveyed hurriedly most of the indictment brought against civilization. A little reflection will show that this may be summed up under four heads. (1) Invention is checking favorable variations and creating an artificial rather than a natural condition. (2) Science and philanthropy are preserving unfavorable types which

tend to reproduce faster than the superior and will in time therefore drive out the better. (3) Social arrangements have destroyed the struggle for existence on which progress depends. (4) Civilization is destroying itself.

It is apparent to the careful reader that a large part of the indictment is based upon an older biology which, as has been shown, is no longer accepted by biologists. It may be that the eye will not become better adapted to the newer tasks and will not improve. But we now know that new uses have never caused favorable variations. Variations are not dependent upon use. We have a thumb which may be made to oppose the other fingers and to this fact we owe much of the value of our hands. There is no reason to assume that the attempt of early animals to cause such an opposition of thumb and fingers produced the variation. In fact, we know nothing of the cause of variations, but it is certain that use and disuse are not responsible.

In like manner there is no reason to assume that modern industrial conditions, admitting the worst that can be said as to their responsibility for accident and disease, are causing a progressive degeneration of the race stock. This cannot be construed into an argument for permitting bad working conditions which injure workers. It is merely a recognition that the problem belongs in the realm of the environment, not in that of heredity. In other words, if the sons of the crippled and diseased miners and toilers about whom England has recently been concerned are put under good living conditions they will display the same old vigorous stock which was the pride of the country. Australia, Canada and America are but illustrations of what a good environment will do for good stock.

We are not here concerned with the question as to

whether the weaklings should be cared for or destroyed. We do recognize frankly that the forms of degeneracy due to heredity, like feeble-mindedness, should be eliminated from the ranks of parents and here biology has a positive suggestion which society cannot long ignore.

In a word there is in most of the argument against civilization a confusion of cause and effect. There is no good reason for believing that the race stock has changed either for the better or the worse in thousands of years. Because we are better fed and live under better conditions we are larger and stronger than our ancestors. Few men of today could even get in the armor of the knights of a few centuries ago. Because we are better cared for we have doubled the length of life on the average and population has tremendously increased. Because we care for the sick and crippled they too survive. When we choose to eliminate the few types of undoubted degenerates whom we have foolishly allowed to reproduce we shall then see more clearly that the great problems of society are created by society; that is, they are the results of social programs which have not brought the greatest good to the greatest number, and this we may assert without quibbling as to the responsibility of the individual man or woman. Sound morals depend on sound brains, plus, let it not be forgotten, sound training.

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## CHAPTER X

### SOCIAL INSTITUTIONS

Many ages ago man emerged from his ape-like chrysalis and began his long journey. Of all the earlier stages the records are gone beyond recall and the story of his career can only be reconstructed in vaguest outlines from the hints given us by existing savages and the application of existing knowledge as to the conditions under which he lived. In this attempt we are likely to fall into serious error because we look at things through our own eyes and we interpret his life both physical and mental in the light of our own experiences.

It seems certain that early man lived in small groups, probably in a warm climate for he was without clothes, and that he lived largely on fruits. We know that in his day he was surrounded by immense fierce animals from which he could only flee when attacked, for weapons of defense were not yet his.

Of necessity then he lived in a world of fear and that emotion must have been dominant in his mind. Driven by this and other emotions, he acts. More gifted in mind than other animals, he considers the results of his acts, both by himself and by communication with his fellows; and discovers that certain acts under given circumstances bring happy results, while others are disastrous. He learns to play, gather food, hunt, fish, etc., in companies and comes to think of the world in terms of others as well as self. Out of this process he finally evolves language,

and out of it too comes that more or less organized method of looking at the world and its problems which we term his philosophy. It must be emphasized that his philosophy is the outgrowth of his acts, his acts in turn are caused by his emotions. He does not start out with a standard set of rules to meet the emergencies of life, but develops such standards as the result of trying to keep himself alive and meet the needs of the body.

At some time he begins to ask himself as to the nature of other forms of life. He sees that animals eat, drink, sleep and perform the other physical functions as he does. He sees in them many of his own emotions. He does things under the stimulus of his emotions; so do they. Hence there is a great resemblance between himself and them. Could he but learn their language he might converse with them. All causes to him then become personal. Even the events of nature which we think of in terms of law are to him but indications of the action of personality. Ultimately he thinks of the world as peopled with spirits or beings without bodies. No one has traced this evolution in happier fashion than Spencer.

The man looks down into the still pool of water and sees a face. He does not know that it is his face. How could he? He knows nothing of the reflection of light, yet there is a face visible to all onlookers. He calls, and from the cliff echoes and reëchoes the sound of his voice and even the very word or cry. Some one is evidently repeating what he has said. Yet no one can be seen. He sleeps, and dreams of some great experience which he tells to his comrades only to be told that he has been asleep all the time and has not moved from the spot. He knows better. Has he not just done this or that, no matter what friends may say? He sees some one in a coma, and

prepares to dispose of the body, when lo, the friend returns to life. Here, then, is the only answer, there must be a spirit within him which is not confined to the body but may wander over earth at will. The Tagalogs of the Philippines today believe that it is dangerous to waken a man suddenly lest his spirit be found absent and dire results follow. So too the awe-inspiring phenomena, fire, thunder, lightning, tornado, even sickness and final death, come to be thought of in terms of persons.

Now, such a development but illustrates the distinction between belief and knowledge. Belief arises from suggestion, discussion, analogy; while knowledge is the result of observation, experiment, comparison. Knowledge must rest on accurate analysis, belief depends on an assumption of accuracy. Belief may lead to knowledge, but it is quite as likely to lead to error. Knowledge may be verified belief, but more than likely it is verified heresy. Belief strengthens with passing years and the longer it is held the less open to evidence the believer becomes. Knowledge is always seeking new tests of its own adequacy. Belief thus becomes a means of checking progress; knowledge demands more knowledge to explain the things as yet not understood. In early man these two attitudes must have been blended and confused as often as they are today but the distinction is clear.

Out of this medley of knowledge and belief arise the customs, folkways, standards and institutions by which man's life is regulated. To them he subscribes and uses all his power to make his children subscribe. Finally these appear as family, church, state and all the rest, occupying more or less distinct fields. Not so in early days. Life is still a unit. There is no clear, sharp thinking from different standpoints, hence there is no definite

separation of the functions of different agencies. They overlap in endless confusion. Only gradually do they assume more specialized tasks and their functions in different lands by no means agree.

In course of time man comes to think of his earthly career as merely part of a continued existence. He portrays the future as offering rewards and punishments for virtue or vice and thus gains a tremendous support for the standards he is attempting to teach the young. Moreover, this conception eases mightily some of his ethical problems. Vice is not always punished on earth, virtue is often its own only reward, but if there is a future life we may expect punishment for the wicked or the oppressor and compensation for the one who has endured hardship here. This leads to the conception that there is a standard of right and wrong not based on the relative and fluctuating conditions of everyday life. All human groups have tried to develop this final standard because of its marked influence on present conduct, if for no other reason.

There arise thus at least three sets of moralities whose interrelations are often confusing. There is first the morality of the group to which any individual belongs. A little contact with other groups reveals the fact that they have their own standards and that they differ in many ways. Above these is the ethical or religious standard which in its turn often differs materially from the other codes. To which of these sets is obedience due? Primitive man has no trouble in answering this question. The code of the outsider has no application to him though it may do for the outsider. Morality lies in the wholehearted acceptance and execution of the group code which is usually thought of as acceptable to God. It is only an advanced society involving many and conflicting elements

that becomes conscious of a final code held as an ideal and often not applicable under present conditions. The moral man then is he who does as the group standards dictate. Added esteem may sometimes be won by doing more than is demanded, never by doing less.

Every child born enters into a world of customs, institutions and ideals which is as real as the physical world itself. If he is to survive and ultimately play his part as a man among men, his adaptation to his social environment must be quite as real and thorough as that to the natural environment. Inasmuch as his social equipment at birth is almost nothing, this means that a long period of training is necessary ere he be fitted to stand by himself.

The human being has an exceptionally long infancy. The average life of an animal is about seven times the period of immaturity. If this were true of man his average age at death would be 120 instead of 40 or thereabouts. This long childhood means, as compared with other animals, a peculiarly close and intimate relationship with the mother, a very slow maturing of the tissues of the body, and above all else, so far as can be seen, an opportunity for that necessary social training on which so much depends. Man must be further developed than other animals ere he can be independent, and civilized man must have more training than the average ere he starts out for himself. The Indian boy of 12 probably knew more of the necessary facts, was better skilled in the necessary arts of life, and stood a better chance of survival if thrown on his own resources than any American boy of 15 or 18. That is to say, the former's training was more complete, which also means that the later developments were far less than is possible now for the American boy. Early maturity means relatively a low grade of accomplishment. In

those callings requiring an exceptional degree of intellectual development the European or American youth of today must be supported by his parents until he is 25 or 30 and even then his own development is far from complete. The mere preparation of a child to lead the "higher life" is an extremely difficult and expensive process, involving endless opportunities for serious and costly mistakes in method, with the possibility of having attempted to make a gander into a swan after all. Disregarding the blunders of judgment, it is clear that only those to whom come the greatest opportunities of training can ever do the most difficult tasks of society.

In addition to the purely personal relationships of parents, children, friends and associates, each child enters a world in which public opinion in many ways has been more or less formally organized. These social institutions are the agencies by which man standardizes and regulates: (a) his adaptation to the physical world; (b) his attainment and use of wealth; (c) his relations to fellow men; (d) his relations to the gods.

Their basis and justification lie in the needs of man, primarily in the great needs of (a) self-preservation and (b) group-preservation or reproduction. Their great merit lies in the fact that in a real sense they represent the collective judgment of the group which is likely to be wiser than that of the individual, particularly the young individual whose outlook on the world is still narrow. "Experience," said Franklin, "keeps a dear school, but fools will learn in no other."

All institutions involve, either directly or indirectly, some constraint over the actions of the individual. The desired conformity to standard may be brought about by the use of force if necessary, as by the state, but more

likely is secured by the mere fact that the average person imitates the habits and customs of his associates. The fear of ridicule, of seeming to be queer makes the use of force unnecessary in the main. In most regards then the average individual conforms to custom because it is easier than non-conforming.

The four great ends of social institutions may now be considered a bit more in detail. As we have seen, life without adaptation to the physical world is unthinkable. We may then consider this as a purely personal question, but it has social aspects as well. Clothing is designed to protect the body but in organized society the wearing of clothing is not wholly left to the wishes of the individual. Out of the habit of wearing clothes arose the ideas of modesty as to the display of the body. Hence social conventions, differing most instructively and amusingly from place to place on earth, require the covering of this or that portion of the body and sharply penalize the one who disregards the edict. In our country the face is not ordinarily covered, but in Mohammedan lands the woman who uncovers her face is considered most immodest. In addition to requiring some clothing, the particular articles to be worn are not wholly decided by the individual. The girl who dresses in boy's clothing is very likely to be arrested. He is a very ignorant or a very bold, confident individual who wears a red necktie when evening dress is expected.

Food may seem to be a personal matter, but it is not. That which may be eaten is largely a matter of custom. Cannibalism has largely disappeared from earth and even in dire emergencies I suppose most civilized persons would starve rather than eat human flesh. We eat crabs and lobsters, but draw the line on cats and dogs. Moreover,

the manner, time and place of eating are pretty carefully regulated by customs which few disregard.

Our bodies, like our clothes, must be washed whether they need it or not, if we are to keep our standing in society. Our houses too are more or less regulated by law and custom.

That these standards have certain great advantages in spite of the amusement they may afford is plainly evident. Just now we are concerned with the fact rather than with the attempt to justify or condemn the results.

One great prerequisite of civilization is wealth. So long as man had to use all energy and time in securing the bare necessities of physical life there was no chance for progress. Whenever and wherever it was possible for him to have a surplus beyond the moment's needs he had a chance to devise ways and means for keeping ahead and to use articles or materials previously unavailable. Now all wealth is produced by the application of man's talents to the reshaping or relocating of natural objects, that is by work. If greater wealth is to be created, his efforts must be more wisely or productively used. If increased efforts either of mind or body are to be secured, greater incentives must be found. Probably the greatest incentive yet devised is private property. There can be no doubt that this like all other institutions was of slow gradual growth. It must have originated in the peculiarly personal objects such as clothing or weapons made by the individual for his own use. Ultimately the idea was extended until it embraced the ownership of the earth itself and included the right to give, sell or transmit by inheritance that which had been accumulated, to others. Yet in all ages society has sought, not always successfully, to

control the method of acquiring property, its use, its disposition.

Even before the existence of private property there was the need of regulating the relations of man to man. The emotions of friendship or of anger might easily lead to results either good or bad from the standpoint of the group. Hence all history teems with illustrations of the attempt of society to secure the acceptance of standards of conduct with reference to others, that the individual and the group might be protected and peace and welfare secured.

It has also been believed that we were surrounded by invisible hosts of beings, of indefinite and perhaps infinite power, both good and bad, whose opportunities for influencing our lives were endless. Hence man's attitude towards these unseen spirits and the effect of his actions upon them have been matters of deep public concern. In no part of our life has there been greater effort than to secure that uniform attitude of respect and worship, of trust and belief considered desirable. Moreover this attempt has been, in the main, wonderfully successful. To such an extent has this effort been carried that not only the outward acts of man have been examined but his mind searched to make sure that his ideas and beliefs were in accord with the accepted standards.

Into this social world, then, man is born and to its decrees he must in the main submit. There is a lot of loose, careless talk today of personal rights, by which expression is meant not the privileges granted to the individual by society but rights that are his because he is. One might as well say that black is white. Rights come from society, are determined wisely or unwisely by society; and to speak of individual rights as other than these

privileges is absurd. I live provided I do or do not do the things commanded or forbidden by society. I can escape only by taking my own life, which is forbidden, or by escaping to some wilderness which no longer exists and to which I do not want to go anyhow. So long as I remain a normal human being, desiring the companionship of friends, I am subject to group control. I may have the power to work my will regardless of group standards, but I exercise that power at my own risk.

Inasmuch as institutions grow out of human needs it follows that once these needs are appreciated and the institutions developed, they must last as long as the need remains. There should be then no anxiety about the permanency of such institutions as family, church and state. He who bewails their decline but betrays his own meager understanding of the situation. What he really means is that the particular form in which he is interested is threatened, which is a very different matter. So long as children must be trained there will be schools, so long as men and women fall in love there will be families, so long as common safety and existence demand protection there will be states, and so long as thoughtful men ponder the nature of the universe and speculate as to its meaning there will be churches. History however teems with records of forms now gone, and the death notices of our own may some day be written and the men of a later age will probably rejoice just as we do when we consider what once was.

Though institutions are organized to meet human needs it by no means follows that they are always beneficial. This may result from several causes. We may make a faulty diagnosis of the situation. To borrow an illustration from the medical field, we may be conscious of in-

tense pain in our bodies which we attribute to something we have eaten when in reality the trouble starts in our defective eyes. Until this fact is discovered our remedies are not likely to give more than passing relief. So we are told of the attempts to stop disease by the hounding of alleged witches; to secure abundant game or harvests by various mystic rites of no real bearing on the situation; to secure rain by prayer or ward off storms by incantations.

Progress may be prevented by the survival of old beliefs and superstitions. The iron plowshare was not invented till late in the eighteenth century and its use was strongly condemned on the ground that it was an insult to God, that it poisoned the soil and made weeds grow. In spite of our present knowledge of disease, charms and amulets find wide use, while "malicious animal magnetism" and the "conjure-man" still dispute the field with the doctor.

The conflict of different standards causes much difficulty. The growing unity of the world through means of communication and transportation is setting various group standards in sharp contrast. When races mingle, as in the United States, there is great danger that many individuals will desert the old morality without adopting the new. This is one of the reasons for that lawlessness which gives us so much concern. The Christian Church deserves great respect, but what must be the reaction of the Chinese or the Indian who sees the many quarrels between Catholics and Protestants, the disputes over apostolic succession or immersion, the emphasis laid upon Trinitarianism or Unitarianism?

The ambition to exercise power is one of the strongest forces in man. Great, well-organized institutions offer a specially favorable opportunity for the exercise of such

power, particularly when they possess inherited wealth. When therefore a professional class is developed, more or less self-perpetuating and self-chosen, there is an almost irresistible temptation to utilize their position for selfish ends. This temptation is strengthened by the fact that they sincerely believe they are the fittest to govern others, that they know what is best for humanity, and that they are exercising their power for the benefit of humanity. When this stage is reached the people are taught that the institution is an end in itself; that they owe a duty to maintain the institution as it is. If this idea is accepted the way of the exploiter is easy. From time to time now this, now that institution has thus been used to further selfish ends, while the people suffer and pay the bills until the day of reckoning comes.

Human nature is one of the most fixed and unchanging elements we know. Our needs and desires are about the same as those of men of eras gone by; our capacity even seems little increased in thousands of years. The high school boy of today knows more of the actual world than Aristotle, but teachers find few Aristotles in their classes. The world in which we live however is constantly undergoing change. If it were not for this fact it would be possible to work out a relatively final and complete adjustment between man and his environment and thus develop a static condition in which we might contentedly follow the practices of our ancestors for countless ages. A few groups, notably the Chinese, have done this. In most cases it has not been possible, in part for the following reasons:

The drying up of Asia, to which reference was made in the first chapter, has set in motion great migrations of peoples who have forced themselves into other civilizations

and caused great upheavals in customs and institutions. Man himself has started many of these changes by his inventions and discoveries which have opened new worlds to his view and profoundly affected the course of his development. Because of these two great sets of causes the environment of man, both physical and social, is usually more or less in a state of flux; hence there is constant need of change if there is to be the desired degree of adaptation between man and his environment.

The problem is further complicated by the increase in size of the units of society. Classes and castes appear, the activities of men are more specialized and that program which may suit one section of a people or country may not meet the needs of other groups or districts at all. Unequal rates of change will appear and general and orderly progress may be impossible.

Hence the course of civilization is not a slow and steady climb on an even grade but must be compared to a trail over the mountains where, after climbing some shoulder for hours till the top is in sight, one must descend many thousands of feet into some ravine ere the road starts upwards again. So complex has the situation become that certain parts of the population may be climbing while others are going down hill; while this may be true even within the individual, when one looks at different parts of his life.

Civilization then involves several distinct elements. There must be the provision of the material bases without which he may not attain higher standards; there must be a dissatisfaction with that which is or man will not put forth the effort necessary; there must be some promise of reward for success, and finally but by no means least, there must be a glimpse of the spiritual values, a willingness to

utilize the gains for the benefit of the body politic, rather than for selfish ease.

Granted the general accuracy of these propositions, it is easy to see that we have not yet arrived at the heights possible nor has the way been uniformly pleasant. Looking back from our present position we catch glimpses of the ground that has been covered and see occasional suggestions in the condition of existing peoples of earlier stages in our life. Here we see a fishing or hunting people in some isolated region, say the Eskimos, following the same methods and maintaining the same level for ages. Elsewhere we see signs of rapid change and marvel at the rapid development of Japan or bewail the downfall of the old Greek culture.

One thing becomes clear. However necessary and desirable is change it brings new problems with it and the most significant results are often not those sought or promised. Few Americans dreamed that the struggle which was to free the slaves would end by making them citizens with theoretically equal voice in matters political. Fewer anticipated that the adoption of the Fourteenth Amendment would lead to the acceptance of the doctrine that corporations were persons in the eyes of the law, while no one probably anticipated the levying of an income tax on all persons. The truth is then that expediency, not some final code of ethics, underlies all changes in social programs and is responsible for many of the resulting problems.

To put it in another way: the older conception was that originally man was pure and undefiled; that he lived under ideal conditions which he lost because of his own wickedness. Then followed an era in which we were taught that man had started from his animal base and

had gradually climbed the heights; but that owing to free will he was able to select either the good or evil with full preknowledge of the results of his acts, and that therefore the evil of the world was of his own creation, even though some still stressed the influence of Satan. The measure of truth in these attitudes does not concern us here, but it is evident that they ignore a larger truth which is becoming ever clearer. The problems of vice, crime and sin have increased with civilization rather than diminished; not because of man's deliberate wickedness, but because of his blindness. In his search for wealth he has ignored the fact that wealth produces problems as well as poverty. Until he sees that the social results of changes in his life require rapid readjustment of his programs and ideals, this paradox will continue. To make this viewpoint clear, let us consider some of the great changes which modern inventions have produced, whether good or bad.

Not long ago the overwhelming mass of people of Europe and America were farmers, living a relatively isolated life in scattered and largely independent households. Each household was a unit producing the bulk of the raw commodities it needed and changing these by a process of manufacture into the clothes or other necessities. The little imported from the outside came largely by trade or barter. The child grew up with the parents sharing their life, learning the processes of industry, seeing and appreciating the meaning of the different processes. The life was simple and self-contained, the groups permanent, blood relationship dominant. Then came the great series of inventions which resulted in machine-facture rather than manufacture. The result of this greatly enhanced power increased the products of labor many fold. In

theory then man might now work shorter hours and have larger returns than before. In part this has proven true but other and disturbing factors have appeared.

Power machinery by centralizing industry compelled a re-location of population and produced the modern city. This forced a specialization in occupation and drew the people away from the land until, as in Belgium the most densely populated country in Europe (659 per square mile), only one-fourth of the people are classed as agricultural and they produce less than one-half of the cereals they consume. By this specialization and the change from a barter basis to cash sale the returns of industry flow into the treasury of the company and the difficulties of a proper and satisfactory distribution among the workers are enormously enhanced. Whereas formerly owner, manager and worker were largely synonymous terms, now three distinct and often unacquainted if not antagonistic groups appear. By specialization, the worker performing only some one or two minute parts of work loses the emotional reaction which comes to the creator of a finished product and comes to think of himself in terms of a machine. Confirmation of this is afforded by an incident which occurred recently in a school for feeble-minded children. Thinking to interest the children and secure some useful products some looms for the making of rag carpets were introduced. The children were given the task of making long strips of carpet. At first all went well, then all interest was lost and no one wanted to work. Inquiry finally brought from a boy the comment, " Oh, you don't never get nothing done." The answer was appreciated — the long strips forgotten. Now only short rugs are made, which one pupil can finish in a few periods, and the looms rattle merrily all day long. Over against the evident and de-

sirable increase in productivity must be set certain great problems which we here list without attempt at solution.

Physical effects: diseases peculiar to occupations such as lead poisoning; accidents due to fatigue; indoor life with the increased liability to germ diseases helped along by lack of sunlight and by dust.

Social effects: congestion in cities; changed conditions of home and family life; problems of labor and capital; problems of industrial organization; problems of vice and crime due in part to breakdown of old associations and institutions; breakdown of old emotional reactions; changed problems of education.

Not one of these great questions of modern life is due primarily to any deliberate selfish attempt to exploit fellow men. They grow out of the changed conditions which no man could foresee, and lacking foresight could not prevent. Yet they must be solved if society is to flourish.

"Progress," says Giddings, "is a form of motion and, like other forms of motion, starts reactions against itself." There are two ways of committing suicide. One may take his life by use of knife or revolver, by a dose of prussic acid and the end comes quickly; or he may gradually poison the system by opium or lead until slow death is produced. It is equally possible for a given society to introduce programs which must ultimately lead to decay even though the separate steps produce no perceptible result. The point is that we must realize what progress costs and stand ready to pay the bills whenever they are presented or else witness the downfall of our culture. There is nothing inherent within us which leads always to right choices or wise programs, whether of the individual or the group. This fact is often ignored.

At all times we find in the community two types of

men, though they may exist in a given man as regards different things, which we may term the conservative and the radical. A comparison of the two is instructive.

The conservative usually comes from a group that has been successful under the old régime. He sees that the old program has worked well for his friends and assumes that it must serve others equally well, or that it is their own fault if it does not. These " others " he seldom knows personally. He does not meet them in his parlors, his clubs or his church. Knowing the value of the old and realizing that new conditions may cause trouble he opposes change, sincerely, though perhaps mistakenly. He believes in his people and his country and is often willing to sacrifice time, money, even life itself if need be. If of extreme type, we call him the reactionary for he would go back to still older standards.

The radical, by contrast, is likely to come from a new and relatively unknown group. He has nothing to lose by change and so welcomes it. He sees that the higher positions are in other hands and believes that this is true because he and his friends have no chance to show what they can do. Lacking power and the restraining influences thereof he advocates change for the sake of change. He may be equally high-minded and patriotic and may see more clearly than his adversary the advantages of the new order. He is less likely however to appreciate the advantages of the present order, and his desire to get a hearing easily leads him to foolish and unwarranted statements.

Where does the truth lie as between these men? It must be confessed that it lies wholly in neither. There have been merits in the present order else it could not have endured. There are social values which must be pre-

served. Nevertheless improvement can only come through change, and therefore the change must come even though it brings troubles in its train.

Man is likely to boast that he is governed by his intellect and that his decisions are based on a careful consideration of the merits of a question. This is seldom true. The dominant forces are emotional not intellectual in the average man at all times and often in the exceptional man. He is a foolish leader of the public who deals with his followers on an intellectual basis solely. He tells them that he will convince their minds but what he really does is to rub their backs the right way. As illustration, the proposed new constitution for the state of New York, so overwhelmingly defeated in 1915, was a vast improvement over the old, regardless of possible weaknesses. It was defeated by the votes of thousands, most of whom it is safe to say had never read it.

It follows then that the solution of social questions lies in the readjustment of institutions that they may more adequately meet present needs. We can neither return to the alleged ideal conditions of the past, nor yet hope for a solution through some panacea which is the forerunner of Utopia.

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## CHAPTER XI

### THE NATURE OF PROGRESS

A million years ago the physical world was in all essentials the same as it is today. It is now what it will be a million years hence, when the things of which even Wells hardly dreams are the commonplaces of every school child. If we compare ourselves with the men of the early days, there is little reason to believe that there has been any great change in our nature or our needs. We require about as much food and drink, we must be kept as warm and we have about the same strength, physical or mental. We seem to be the same in our emotions and their expressions. We are no happier, no more satisfied with life, no less fearful of death. To be sure we no longer consider these matters in quite the same light, but there is no essential difference. Yet no one could claim that great and important changes had not taken place in the conditions of our life. Most of these changes to say the least have been brought about by man himself through his growing control of the physical world. It follows then that the marked changes have been in the field of our information, in our power of achievement. We can do things because we have learned how.

Primitive man must have lived in warm regions until he discovered the art of firemaking and invented clothes. Since that time he has found his greatest opportunities in the temperate zones. Now these are not the richest zones, perhaps, but they are those in which he has found

it easiest to grow his crops and protect himself against his enemies. So far as we can now see there is no inherent reason why he may not ultimately build up great civilizations in the tropics, provided he can guard against the endemic diseases. Nature then may be said to guide the development of a people. She does not directly cause it, for even where she furnishes the most goods in return for the least effort man may nullify the situation by the calm acceptance of a policy of the least possible work for the longest time possible. On the other hand it is hard for her to check it if once man has gotten a glimpse of his own power to modify conditions to his liking.

Because man's progress is conditioned on his intellectual growth it by no means follows that his chief occupation is thinking. Far from it. There is nothing the average society dislikes more. Man's effort to satisfy his emotional desire for an easy and comfortable existence results in the astounding paradox that he opposes the only method through which better adaptation might come. He may be indifferent to studies which have, or seem to have, no practical importance, or may even welcome them and support them as badges of distinction or as an opportunity to display his own generosity. Thus he digs up the bones of the ancients or collects the clothing and utensils of existing savages. He may even openly support any attempt to discover ways and means of bettering industrial processes providing they promise larger returns. He welcomes new ways of spending surplus revenue. Let any one suggest that his philosophy of life rests on unsound bases, that social institutions need radical overhauling, that present programs are not conducive to human welfare, that other races are surpassing his in the struggle, and he is on the defensive at once, ready to use any brick or cudgel on

the offender, or even daub him with mud. The last thing it occurs to him to do is to admit that the criticism may be honest and investigate it to see what merit it contains. This attitude is to be found in all races and in all stages of society and adds much to the joy of life to him who has a sense of humor but adds much to the needless burdens of life as well.

The great contrast in the intellectual life of civilized men as compared to savages lies in the superiority of the tools with which the former work. For long ages the keenest and wisest men have been working in the different fields of knowledge and have accumulated a mass of information. This has been examined and criticized from all angles until that which remains is in large measure capable of definite proof. It is this which is taught the oncoming generation as truth and which is accepted by them and used as the basis of their studies. It follows then that we all embody in our explanations the theories which we have learned. We cannot take the time to furnish all the evidence for every claim. "We are only too apt, however, to forget entirely the general, and for most of us purely traditional, theoretical basis which is the foundation of our reasoning, and to assume that the result of our reasoning is absolute truth. In this we commit the same error that is committed by all the less civilized peoples. . . . There is an undoubted tendency in the advance of civilization to eliminate traditional elements, and to get a clearer and clearer insight into the hypothetical basis of our reasoning. It is therefore not surprising, that, with the advance of civilization, reasoning becomes more and more logical, not because each individual carries out his thought in a more logical manner, not because the traditional ma-

terial which is handed down to each individual has been thought out and worked out more thoroughly and more carefully." [1]

In the above paragraph Professor Boas calls attention to two great truths, both of which are often ignored. Our own thought rests on certain concepts such as the doctrines of the sun-centered universe, or the doctrine of physical evolution. We simply assume these as the common basis of discussion among educated men. We do not stop to prove them; indeed many who lightly take them for granted would find extreme difficulty in offering acceptable evidence. To most of us then they are traditional, as truly as the earth-centered, special creation concepts were to men of the older time. The advantage most of us have over the men of the older time lies in the criticism to which the older views have been subjected and to the fact that a clearer perception of the truth has resulted from the criticism. Our traditions are better, hence our views are more accurate. Had we lived in the older time we should have accepted the then current tradition with as little question as we now show to present tradition.

If knowledge has been the key to the changes, why has there not been a constant, even if irregular, ascent of the race? The answer lies close at hand. Knowledge is not always equally appreciated or evenly distributed, nor is it always wisely used. Every change in the possibilities of a group requires a corresponding change in its programs and ideals, else there is trouble rather than advance. Because of the emotional hold of old beliefs and customs knowledge often appears as a disturbing element and does not get a proper hearing. Inasmuch as the average man considers existence as most fundamental,

1 Boas, F. The Mind of Primitive Man, pp. 205–206.

new knowledge is probably more welcomed in the field of industry than anywhere else.

In no small measure due to the industrial development which increasing knowledge has made possible, there has been an enormous enlargement of the groups which function as units. In early stages there is a small circle of parents and children more or less fused with, more or less distinct from, the larger clan or tribe. In fact, or in belief, they are all related by descent. At this stage all virtues and vices are personal, individualistic. Personal might rules in all conflicts, determines all vexed questions, is the basis of social standards. Yet even here the necessity of caring for children is beginning the development of other ideas. As the groups grow in size group virtues emerge. Duties are owed to fellows of the group which are not owed to outsiders. The group becomes the nation and the group virtues are summed up in the word "patriotism." Now a certain geographical area is the outer fringe of the field of many virtues both positive and negative, or the country is symbolized by a flag and extends wherever the flag flies. But the world through commerce and easy communication, through books and the knowledge of common languages, tends to become a unit; and feeble germs of international law arise as if spontaneously; but alas! lacking father and mother to fight for them, they quickly perish in a world still mainly interested in home affairs. The ground gained, however, is never wholly lost and age after age the essential unity of the race is seen.

Just a century ago the great Cuvier said that to speak of a science of geology was to invite ridicule. The average man of today thinks that it is as old as the hills. In our own days the attitude of Cuvier is the common

one manifested towards the social sciences, especially sociology. If human actions, group actions as well as individual, are governed by law, if like causes under like conditions produce like effects, there will ultimately arise a science of sociology. It is amusing to see many men denying the possibility of such a science and then turning around and telling just what courses society should follow, what standards it should adopt. With the details of the struggle to develop such a science we are not now concerned but certain of the views suggested are pertinent to the discussion.

The acceptance of the doctrine of physical evolution was accompanied and paralleled by the application of a similar idea to things social. Not only was the body of man made subject to the laws of the organic world, but the development and decay of his institutions, such as church and state, was explained in organic terms. This hardly expresses the full truth for it was taught that social organs *were* organisms, and there thus arose the "organic theory of society" whose leading champions were Schaeffle, Spencer and Lilienfeld. It is not suggested that these men thought of themselves as biologists nor that they really meant to do more than take advantage of existing interests to suggest that society was analogous to an organism and to trace this analogy as far as possible. Much foolishness has resulted from a too literal interpretation of their writings. It must be admitted that the writers mentioned have sometimes laid themselves open to such misinterpretation.

Spencer was primarily interested in tracing the structure of society and his central idea, as Small well puts it, is: "The members of society, from the very earliest stages, arrange themselves in somewhat permanent forms;

these forms rearranged in adaptation to varying needs; the forms are related, both as to cause and effect, to the individuals who make up the society; they are thus factors that may never be left out of account in attempts to understand real life.[2]

Society is like an organism in that it grows; and as it grows the parts become unlike and their functions change. Hence there comes to be mutual interdependence of parts. Some great disaster may wipe the society out of existence, but barring this it lives longer than the individuals composing it. Societies begin in small units which grow. Growth is accompanied by increasing complexity of structure. The growth may be through the multiplication of groups or the increase by union of groups. As mass increases structure becomes more compound and with mutual dependence the parts become unlike. Like organisms, society must have a sustaining system which consists of the productive industries; a distributing system which embraces communication and commerce and a regulating system, i.e., government. Spencer thought that earlier society had been primarily military, that is, had been mainly concerned with the protection of the group or the acquisition of territory. He said there was a gradual change to an industrial society which necessitated larger coöperation and a consequent modification of the sustaining, regulating and distributing systems. This also meant a steady move from the simple to the complex in accord with his conception of evolution.

The man who broke away from the dominant influence of Spencer was a trained scientist, Lester F. Ward, who published in 1883 his "Dynamic Sociology." In this

[2] Small, A. W. General Sociology, p. 153.

he undertook to make a sharp distinction between the evolution of the world of nature and the world of society. The latter is due to the great development of mind so that man in a sense becomes master of the universe and shapes it as he will through his power of achievement. While achievement through man's intellectual development is the key-note of Ward's philosophy, other men have not failed to bring out other of the psychic elements now so largely emphasized. Giddings has made "consciousness of kind" the basis of his system; Tarde has compelled recognition of the rôle played by "imitation," while Ross has emphasized the necessity of "social control."

Sumner and his successor Keller have broken away from the cruder comparisons of the older writers who emphasized the biological factors. They recognize that man is fundamentally an animal, that he is under natural laws, and that his attributes, emotions, passions are likely to remain what they are regardless of his social evolution. Thus Keller writes: "I shall be charged, doubtless, with 'reasoning from analogy,' but I do not feel that the charge is deserved. I find a something in the social field which *is* variation, whether or not it may be *like* what is called variation in the organic field; similarly social selection *is* selection and not merely *like* it. In the social field, also, there is a means of transmission having the essential attributes of heredity in nature; and adaptation occurs in one range of phenomena as in the other." [3]

"We see that man possesses in the brain a sort of specialized adapting organ which relieves the rest of the body from the necessity of structural adaptation; that

[3] KELLER, A. G. Societal Evolution, p. 15.

the human mode of adaptation is thus mental, and that it is also social; that the measure of human adaptation is the degree of civilization attained; that the story of human evolution thus becomes the story of the evolution of civilization in human society; and that the law of population must receive characteristic modifications when it is applied to man. The brain becomes *the* organ of adaptation. Looked at in one way it secures adaptation for man by transforming his environment; but in a broader and truer sense, by learning the laws of nature and devising ways of conformation to them. But the details of this new phase and mode of adaptation are no longer matters of biology; the reactions of the individual are cerebral and psychical. However, these reactions do not remain individual and isolated, but . . . they become societal and so fall into the domain of sociological study." [4]

What we really have, according to Keller, is the change from habits, folkways, into group-customs or mores. These are selected only in part on rational grounds, mainly on emotional. Some of them are better than others, the mores of one group may be much better than those of another. In times of trial the group with weak mores either discovers its weakness or, in extreme cases, is destroyed because of them. This revelation of weakness Keller thinks has always been one of the chief services of war.

A different application of biological principles, real or alleged, to social questions is to be found in a large number of writers, philosophers and statesmen who are advocating what they call "social Darwinism." Speaking in simplest terms, it is the application of the law

[4] KELLER, A. G. o. c., pp. 39–41.

of struggle to human relations, particularly in international affairs. The stronger, abler race will survive, the weaker be destroyed. You may be sorry for the weaker but it has no claim to a place on earth unless it chances to accord with your own interests. Military necessity overrides all other considerations.

The first thing to attract our attention in this philosophy is that it was not held by Darwin, Wallace, Huxley and Kropotkin. Darwin believed in coöperation, not war. He wrote to Wallace that "the struggle between the races of man depended entirely upon intellectual and moral qualities." [5] The ablest writer from this standpoint in recent years has been the Russian, Novicow, (to use the French form of his name). Into the merits of the controversy we need not go. It is sufficient to indicate the fact that some of the ablest natural scientists disown the very popular doctrine of force which political scientists have claimed as one of their cardinal beliefs. The object of man's struggles, say the former, should be the conquest of nature, not the overthrow of fellow man. In this struggle there should be division of labor and not ruthless competition. The enemies of man are not fellow men but the forms of life which live at his expense.

Whatever the final decision in these matters, there are certain dangers in the attempt to apply the laws of one science to the phenomena of another, of which one of the best living natural scientists, Professor J. A. Thomson, of Aberdeen, has written:

"The fallacy of regarding sociology as no more than a recondite branch of biology is not merely verbal, implying differences of opinion on the tedious question of the best definitions of these two sciences; it involves a mis-

[5] Life and Letters of Charles Darwin, p. 271.

conception of what human society is, a misconception which is discredited by the facts of history and experience. No one doubts that the life of a social group is made up of a complex of activities of individual persons — but these are integrated, harmonised, and regulated in a manner as far beyond present *biological* analysis as the integration, harmonization and regulation of the chemical and physical processes in the individual organisms are at present beyond *mechanical* analysis. . . .

"To keep to the concept of selection for a moment; it was applied to plants and animals, it was illustrated, justified if not demonstrated and formulated; and now with the imprimatur of biology it comes back to sociology as a great law of life. That it is so we take for granted, but it is surely evident that in social affairs, from which it emanated as a suggestion to biology, it must be reverified and precisely tested. . . . In any case, a formula borrowed from another science and applied to a new order of facts — even to those in which it first arose as a suggestion — must be rigorously tested. Otherwise, both organic and social sciences resolve themselves into sociomorphic illusions." [6]

Personally, I have no doubt that we shall develop a science of society. This will involve the collection of much more and more accurate data than we now have. When that time comes, we shall be better able perhaps to compare the relative importance of the forces influencing society than is now possible, for all our explanations today are but guesses. The significant thing is that we are coming to believe in cause and effect in the social realm and to ask for evidence rather than dogma.

This development of a science of society is quite cer-

[6] Thomson, J. A. Heredity, pp. 510–512.

tain to compel the surrender of many hoary beliefs and prejudices. We have seen that it is no more *natural* for animals to serve as food for man than for man to act in the same capacity for animals. Disease and death are as natural as life. Indeed, a vague recognition of this fact has led to the notion that nations like individuals had their foreordained period of growth and maturity to be followed by decline and downfall. All that is here desired is to recognize that evolution and progress are not synonymous terms.

In spite of the fact that a learned historian like Mommsen despaired of ever determining the causes of the downfall of the Roman Empire, in the effort to explain why the leadership of the world has removed from one area to another, from one group to another, the favored answer of the historian has been: race superiority and moral decay. The leading races were obviously superior races. Of this attitude Emil Reich has written: "The most ingenious books have been written endeavoring to apply the theory of race to the explanation of the rise of the intellect among nations. But the racial theory has been ridden to death. After a long struggle, it is now being eventually abandoned by its most fanatical adherents in the ranks of modern historians. But the average man still pins his faith to it. The ordinary Englishman still attributes, and will continue to attribute, the success of his nation to the predominance of the Anglo-Saxon stock; there is something extremely flattering to national pride in the notion. It also permits of a rapid and complete annihilation of the so-called Latin races. The Frenchman is also fired by a kindred admiration for all that has issued from the Gallo-Roman blood, a theory which also allows the equally rapid and complete dis-

posal of all that is Teutonic and Anglo-Saxon. We have already shown how absolutely impossible and inapplicable such theories are in the scientific study of history. Race is quite impossible of identification, and where we can to some extent follow out the lines of ethnographical demarcation, it does not in any way correspond with the national frontier." [7]

Reibmayr would modify the racial theory by saying that civilization is only attained by a people which has remained isolated long enough to have completely absorbed all the various strains that may have entered into its makeup, and then, by keeping others out, has developed along the lines of its own genius. The ancient Israelites were confident that they succeeded when they followed the commands of God, and moralists have not failed to suggest the same reason as regards other peoples. Reich would have it that the "*initiators* of great intellectual progress have been border nations. Situated upon the confines of some great empire, they have also been, on the whole, comparatively insignificant nations on the score of numbers. . . . But it may be laid down as a principle that progress of intellect has always been manifested in response to some external stimulus. Let us consider for a moment the conditions of existence of border nations. Their numbers will not permit them to sustain a struggle of main force against their more powerful neighbors; they must seek for some efficient weapon with which to ward off the onslaught of their outnumbering foes. The only such weapon is to be found in a superior intelligence; directly intelligence stands at a premium it begins to appear." [8]

[7] Reich, Emil. Success among Nations, pp. 115–116.
[8] Ibid., pp. 116–117.

Woods, while not stressing the differences between the different peoples, believes that the strength or weakness of the ruling dynasties largely explains the success or failure of the various nations. "I have just completed a research . . . covering the history of fourteen countries of Europe; 366 reigns or regencies are included, and not over seven per cent can be cited as exceptions. In ninety-three per cent of the cases a single personality is the cause of, not the conditions, but the changes in the conditions from one period to another. The rise and decline of Spain and Portugal, Sweden and Turkey, the cumulative but spasmodic growth of France, the early, slow, but finally accelerating growth of Prussia and Russia, the evanescent importance of the Dutch, the retarded development of Scotland, the comparatively negativeness of Austria, the unexpanded state of Denmark, these are all paralleled in the personalities of the leaders." [9]

Another type of explanation lies in the emphasis put upon external conditions of soil and climate by the anthropo-geographers. If their extreme claims were to be accepted one could tell in advance from the physical background the nature and form of the state in all her activities. It must be confessed that the explanation seems at times too simple to be real.

Personally, I fear that we are not yet in a position to determine the exact rôle of the various causes which have operated in the past, let alone make predictions for the future. Rather, it seems wise to me to try to determine what forces have been at work and what difficulties have been encountered on the road to civilization. So far as I can see the actual progress of a people, up or

[9] Woods, F. A., in Problems in Eugenics, p. 252 ff.

down, has turned upon the conditions surrounding it at any given time. Even assuming native capacity which there seems little reason to question, there can be little or no advance if the external conditions of nature are too severe. It is hard for civilized man with all his boasted superiority to suggest how the Eskimo might improve his standard of living save by trading with the natives of other climes. So far no people in the disease-swept tropics has gone far towards the creation of a great nation. Even where natural conditions are favorable there may be little progress if the wealth created is certain to be stolen by stronger robber tribes. In either case a standard of relative idleness and non-productivity may arise and become traditional. On the other hand, even if the locality be poor there is a chance for development if ideals of labor and thrift are shared by the people. Thus parts of New Jersey are becoming prosperous because of the presence of Italian peasants with simple ideals and relatively low standards of expenditure. The important thing is then the combination of opportunity with ideals. Opportunity stands in close relationship with intellectual development. There is no opportunity for the development of the use of metals when a people does not know the ores or the compounds, no matter how abundant the elements are.

In older times when the groups were less extensive and less inclusive the personal virtues were strongly emphasized. When only the individual or at most his private family suffered, drunkenness was little esteemed. Now, with existing industrial organization it is a matter of concern to hundreds who never see or know the individual in daily life, whether the engineer of the train be drunk or sober. Drunkenness takes on a new guise. The point

is that new conditions demand new standards of personal conduct. A man may be the embodiment of all the old personal, homely, negative virtues, a member in good standing of all orthodox institutions, kind to family and friends, who nevertheless is more injurious and harmful to society than many a despised reprobate, provided that under present conditions he exploits child labor, underpays his female employees, holds public office as a source of personal revenue or misstates the truth in his newspapers to conciliate his advertisers.

I do not believe that it is possible today to establish any definite tests of the fitness of a people or nation to survive. It does seem possible to suggest some of the elements which must enter into our estimates and I list a few without any attempt at arranging them in any special order purely for purposes of illustration.

Inasmuch as the permanency of a society turns in large measure upon the maintaining of right relations between individuals we may say that the first test lies in its choice of the right virtues and right crimes. It is entirely possible that the crimes selected may really have very little to do with the welfare of the people while indifference is shown towards other acts which are very harmful. The New England colonies often forbade the entertainment of a stranger from another colony without the providing of bonds or special permission of the town fathers, but permitted the owning of slaves. Later the colonies objected to slave-holding, but raised few obstacles against the carrying on of the slave-trade by its citizens, or the manufacture and transportation of the rum which was used as purchase money in Africa. The attempt to carefully regulate the sale of goods or the behavior of people on Sunday may often be accompanied

by an indifference as to the condition of the schools for the Negroes, let us say, or the enforcement of compulsory education laws. Chinese gambling joints are often raided while the open gambling in the political clubs of the city is ignored.

As von Ihering pointed out years ago there is a direct relationship between the general economic and social conditions and the crimes most severely punished.

"Every state punishes those crimes most severely which threaten its own peculiar condition of existence, while it allows a moderation to prevail in regard to other crimes which, not unfrequently, presents a very striking contrast to its severity as against the former. A theocracy brands blasphemy and idolatry as crimes deserving of death, while it looks on a boundary violation as a mere misdemeanor. (Mosaic Law.) The agricultural state, on the other hand, visits the latter with the severest punishment, while it lets the blasphemer go with the lightest punishment. (Old Roman Law.) The commercial state punishes most severely the uttering of false coin; the military state, insubordination and breach of official duty; the absolute state, high treason; the republic, the striving after regal power; and they all manifest a severity in these points which contrasts greatly with the manner in which they punish other crimes. In short, the reaction of the feeling of legal right, both of states and individuals, is most violent when they feel themselves threatened in the conditions of existence peculiar to them." [10]

A second test of society is the protection it affords to the lives and bodies of its members. In older times this was largely a question of defense against external enemies.

[10] VON IHERING, R. Struggle for Law, pp. 45–46.

In the great nations of today it is more usually a question of protection against inner enemies. In the United States there are yearly some million and a half deaths of which experts say at least one-third are unnecessary with present knowledge. From the social standpoint the death-rate is perhaps the least of the evils involved. For every death there are many cases of sickness and preceding most deaths is a period of illness. The resulting burden on the wage-earner and the community is terrific. Preventable sickness and death involve the upset of family life, the dropping out of school of many children, the neglect of others because the surviving members have to go to work, all of which results in the formation of shiftless and anti-social habits whose final cost cannot be estimated.

A third test is in the training of the children that they may be prepared to maintain the society when they are grown. If proper facilities are not provided, if the training is not compulsory and not thorough, no one can expect steady social advance or even the maintenance of present standards. Children of primitive societies easily saw the reasons for the standards adopted since most of them turned on methods of obtaining a livelihood. In civilized communities the sense of relationship is lost and the child must accept the verdict of adults that the things taught will be found of ultimate value. Where this is not true or where it is not accepted the educational program is defective to say the least.

A fourth test lies in the elimination of the unfit. The meager surplus of primitive man often left him no alternative but the destruction of those no longer able to do their share, whether as a result of sickness, accident, or design. Civilized man, who has come after ages of

struggle to the acceptance of a belief in the sacredness of human life, may well hesitate to jeopardize that ideal by the ruthless sacrifice of weaklings. Furthermore, such a program would turn against society many of the friends and relatives of those to be sacrificed. Above all else it is no longer necessary, for now our surplus is great enough so that their lives can be spared without undue sacrifice on the part of the rest. Moreover we may perhaps learn from our efforts to care for the afflicted and to cure them, how to avoid certain of the troubles by a change of habits and to deal with the normal to greater advantage; and may develop our altruistic instincts as well. This does not mean that we should tolerate the unfit in the ranks of parents, nor in the ranks of labor, thus reducing our standard and the speed of the group, nor in the ordinary social groups where their presence would give offense. Rather it implies that we devise for each type some suitable retreat where they may be well cared for at moderate cost. The great truth we must learn is that they must be eliminated from ordinary pursuits of everyday life or they will threaten our very existence.

The fifth and perhaps the crucial test concerns the power of readjusting institutions and programs to meet changing conditions of life. On all sides one can see the survival of old standards, old methods, old ideals, which seem to have little to do with present conditions of life. For illustration, our public school system runs merrily on, every train on the road being labeled "This way to the College," though as a matter of fact nearly 97 per cent of the trains are empty when the high school station is passed. We teach the children the glories of the ancestors who fought for freedom from Great Britain

and tell them also of the duty we owe to the poor "Filipino."

It is right at this point that belief and knowledge, emotion and intellect, have always had their fiercest fights. One need not be surprised at this. Here is the parting of the ways. The defenders of the old order make their last stand, sincere in their belief that the suggested change spells disaster; convinced, and not always without reason, that the protagonists of the new order do not know what the results thereof will be.

The poet may have the faith and inspiration to sing:

> "The old order changeth, yielding place to new,
> And God fulfills himself in various ways
> Lest one good custom should corrupt the world."

But the average man is skeptical and hesitates about leaving this world even when convinced that heaven is ready for him just across the river.

The truth is then that in every society there is almost certain to come a period of crystallization of institutions when they cease to meet the real, vital needs of the people. This result may come from many causes. Inherited wealth may remove the necessity of securing constant support from year to year from those whom they serve. Under such conditions the managers become more and more indifferent to popular desires and are likely to be more interested in maintaining traditional programs than in meeting new issues. Again the management may fall into limited groups and descend generation after generation as a closed corporation. Regardless of the intentions of the managers, there is little likelihood that they will know or understand changed conditions and hence will not provide for them. Again, men may be kept in con-

trol long after the active constructive period of their lives has passed, and only when the test comes are their shortcomings revealed. The wholesale replacement of generals in the French army after the outbreak of the present war is a case in point. Most to be feared of all dangers is perhaps the change of attitude on the part of the people who come to revere an institution to such an extent that it is regarded as an end in itself. Blind devotion inevitably bodes disaster which may come in two ways. There may be such power manifested by the institution that all efforts to remodel it or to escape its penalties may be vain. Its power remains but its source of strength is destroyed. Sooner or later an explosion from within results or an outside invader reveals the essential rottenness of the situation. A vast nation of enormous inherent power must bow to the wishes of a handful of Japanese or lease territory to Germany or to England because her institutions were devised to cope with the world of ages gone. Until the outside pressure comes the essential weakness may not be apparent, and a deadly caste system may arise as in India, where for ages things go on as they did in older days. Decay may be checked or concealed but so are progress and development. That which was good has become the enemy of the better.

The truth is that man is likely to forget that he lives in a world of change. No matter how satisfied he is with present conditions or with present forms of institutions he must prepare for the inevitable. Assume if you please that a given people has reached an ideal state and that justice and satisfaction are achieved. Does not the history of the world show that sooner or later an outside people, ambitious and energetic, willing to fight and sacrifice, are likely to enter this fool's paradise and

lay it to waste? The rest of the world has to be taken into account when we shape our policies whether we like it or not. We have passed the time when we think that might alone makes right, but we have not yet fully learned that right must be supported by might if it is to be maintained. International law will continue to be a farce until there are nations willing to support it by all the might at their command.

An added danger comes from the temptation to believe that the loud shouting of old watch-words and shibboleths is a guarantee of their continued vitality and effectiveness. In America we talk much of equality before the law and of justice, and forget that the incoming immigrant hordes get their conceptions of justice from actual contact with the minor courts and are often impressed with anything but justice. Our political leaders wave the flag and shout democracy as loudly as any man on the street, but are often much more interested in their profits than in the welfare of the community.

Out of all the vast turmoil of conflicting interests, of the mists of ignorance and superstition and the test tube of the scientist, must be evolved not merely the material basis of our life, but also the customs and policies which are to meet present needs and help us prepare for needs yet to be. When one thinks of the opportunities for mistakes, of the little learning of the many, and the age-long distrust of those who do know, of the difficulty of distinguishing the last from those who claim to know but do not, we need not be surprised that actual societies have had to "worry along" as best they could until the testing time came. Then perhaps they find the right leader and adopt the right policy in time, perhaps they fail and yield place to some other group. Both have happened in

the past, both are happening before our very eyes. The future belongs to those groups which make the right choices. Today there is little knowledge kept hidden within a given country. Today there is less chance than ever for the maintenance of a stone wall of exclusion. The world is becoming one and the peoples that refuse to recognize this fact and persist in maintaining lower standards are but writing their own death notices, no matter how long the funeral is postponed.

The success or failure of a civilization then cannot be accounted for in terms of race or environment alone. It is far too complex for that. Rather must we account for it in terms of adjustment between man's institutions and his environment which is in part physical, in part social. It is easier to maintain the lower levels of savagery and barbarism than the higher levels of civilization. This is true regardless of the stock of humans. In the simpler stages there are fewer adjustments to be made and the individuals stand or fall as individuals. In the higher stages there are many actors to be harmonized. Group interests often conflict with national. It is more difficult to know the facts, it is vastly more difficult to secure that united attitude which makes possible the use of known facts. That which makes it possible to attain civilization is that the basic factors are after all relatively few and constant. That which has made it so hard to preserve a culture once gotten must be the introduction of so many factors, relatively small in themselves, but which collectively are so important; particularly when the tendency of all institutions is to lose their early adaptability and crystallize.

Ever and anon there arises a man, or a school of men, who have some one remedy for social evils which adopted

will lead to absolute peace and prosperity. If eternal change is the order of nature, there can be no such solution of our difficulties. Adopt democracy and there are left plenty of political problems, some of them unsuspected before. Adopt anarchy, socialism, single-tax or any other of the compounds advocated today and the result will only be a new set of problems for the future to solve even assuming that the immediate results are good. This merely means that there are no final solutions for social ills. We must always be prepared to modify our programs in the light of experience and in accordance with the end we seek to accomplish.

The road from savagery to present civilization has been long, needlessly long, but the road to that civilization which we see as possible in the future is still longer. There is no reason for pessimism. Man can do much greater things than he has done if he will and if he is ready to pay the necessary costs of greater research and greater training, both in knowledge of fact and of purpose; provided always that he keeps faith in human nature and the possibility of human achievement which after all is the essence of religion.

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